The Progenitor Masses of Wolf-Rayet Stars and Luminous Blue Variables Determined from Cluster Turn-offs. I. Results from 19 OB Associations in the Magellanic Clouds

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ABSTRACT

We combine new CCD *UBV* photometry and spectroscopy with that from the literature to investigate 19 Magellanic Cloud OB associations that contain Wolf-Rayet (WR) and other types of evolved massive stars. Our spectroscopy reveals a wealth of newly identified interesting objects, including early O-type supergiants, a high mass double-lined binary in the SMC, and, in the LMC, a newly confirmed LBV (R 85), a newly discovered WR star (Sk$-69°194$), and a newly found luminous B[e] star (LH85-10). We use these data to provide precise reddening determinations and construct physical H-R diagrams for the associations. We find that about half of the associations may be highly coeval, with the massive stars having formed over a short period ($\Delta\tau < 1$ Myr). The (initial) masses of the highest mass *unevolved* stars in the coeval clusters may be used to estimate the masses of the progenitors of WR and other evolved stars found in these clusters. Similarly the bolometric luminosities of the highest mass unevolved stars can be used to determine the bolometric corrections for the evolved stars, providing a valuable observational basis for evaluating recent models of these complicated atmospheres. What we find is the following: (1) Although their numbers are small, it appears that the WRs in the SMC come from only the highest mass ($> 70\mathcal{M}_\odot$) stars. This is in accord with our expectations that at low metallicities only the most massive and luminous stars will have sufficient mass-loss to become WRs. (2) In the LMC, the early-type WN stars (WNEs) occur in clusters clusters whose turn-off masses range from $30\mathcal{M}_\odot$ to 100 $\mathcal{M}_\odot$ or more. This suggests that possibly all stars with mass $> 30\mathcal{M}_\odot$ pass through an WNE stage at LMC metallicities. (3) The one WC star in the SMC is found in a cluster with a turn-off mass of $70\mathcal{M}_\odot$, the same as for the SMC WNs. In the LMC, the WCs are found in clusters with turn-off masses of $45\mathcal{M}_\odot$ or higher, similar to what is found for the LMC WNs. Thus we conclude that WC stars come from essentially the same mass range as do the WNs, and indeed are often found in the same clusters. This has important implications for interpreting the relationship between metallicity and the WC/WN ratio found in Local Group galaxies, which we discuss. (3) The LBVs in our sample come from very high mass stars ($> 85\mathcal{M}_\odot$), similar to what is known for the Galactic LBV η Car, suggesting that only the most massive stars go through an LBV phase. Recently, Ofpe/WN9 stars have been implicated as LBVs after one such star underwent an LBV-like outburst. However, our study includes two Ofpe/WN9 stars, BE 381 and Br 18, which we find in clusters with much lower turn-off masses ($25 - 35\mathcal{M}_\odot$). We suggest that Ofpe/WN9 stars are unrelated to "true" LBVs: not all "LBV-like outbursts" may have the same cause. Similarly, the B[e] stars have sometimes been described as LBV-like. Yet, the two stars in our sample appear to come from a large mass range ($> 30 - 60\mathcal{M}_\odot$). This is consistent with other studies suggesting that B[e] stars cover a large range in bolometric luminosities. (4) The bolometric corrections of early WN and WC stars are found to be extreme, with an average BC(WNE)=-6.0 mag, and an average BC(WC4)=-5.5 mag. These values are considerably more negative than those of even the hottest O-type stars. However, similar values have been found for WNE stars by applying Hillier's "standard model" for WR atmospheres. We find more modest BCs for the Ofpe/WN9 stars (BC=-2 to -4 mag), also consistent with recent analysis done with the standard model. Extension of these studies to the Galactic clusters will provide insight into how massive stars evolve at different metallicities.

Subject headings: Magellanic Clouds — stars: early-type — stars: evolution — stars: Wolf-Rayet

1. Introduction

Conti (1976) first proposed that Wolf-Rayet (WR) stars might be a normal, late stage in the evolution of massive stars. In the modern version of the "Conti scenario" (Maeder & Conti 1994), strong stellar winds gradually strip off the H-rich outer layers of the most massive stars during the course of their main-sequence lifetimes. At first the H-burning CNO products He and N are revealed, and the star is called a WN-type WR star; this stage occurs either near the end of core-H burning or after core-He burning has begun, depending upon the luminosity of the star and the initial metallicity. Further mass-loss during the He-burning phases exposes the triple-α products C and O, and results in a WC-type WR star. Since the fraction of mass that a star loses during its main-sequence evolution depends upon luminosity (mass), we would expect that at somewhat lower masses evolution proceeds only as far as the WN stage. At still lower masses a star never loses sufficient mass to become a Wolf-Rayet at all, but spends its He-burning life as a red supergiant (RSG). Mass-loss rates also scale with metallicity as the stellar winds are driven by radiation pressure acting through highly ionized metal lines. Thus the mass-limits for becoming WN or WC stars should vary from galaxy to galaxy, and with location within a galaxy that has metallicity variations.

Studies of mixed-age populations in the galaxies of the Local Group have confirmed some of the predictions of the Conti scenario. For instance, the number ratio of WC and WN stars is a strong function of metallicity (Massey & Johnson 1998 and references therein), with proportionally more WC stars seen at higher metallicities, suggesting that the mass-limit for becoming WC stars is somewhat lower in these galaxies. Similarly the relative number of WRs and RSGs is correlated with metallicity, and there is a paucity of high luminosity RSGs at high metallicities (Massey 1998a), suggesting that these high luminosity stars have become WRs rather than RSGs.

However, fundamental questions remain concerning the evolution of massive stars:

(1) What is the role of the luminous blue variables (LBVs)? These stars are highly luminous objects that undergo photometric "outbursts" associated with increased mass-loss (Humphreys & Davidison 1994). Are LBVs a short but important stage in the lives of *all* high mass stars that occur at or near the end of core-H burning? Recent efforts have linked some of the LBVs to binaries, as Kenyon & Gallagher (1985) first suggested. The archetype LBV, η Car, may be a binary with a highly eccentric orbit (Damineli, Conti, & Lopes 1997), but whether its outbursts have anything to do with the binary nature remains controversial (Davidson 1997), as does the orbit itself (Davidson et al. 2000). Similarly, the WR star HD 5980 in the SMC underwent an "LBV-like" outburst (Barba et al 1995); this star is also believed to be a binary with an eccentric orbit, although the nature (and multiplicity?) of the companion(s) remains unclear (Koenigsberger et al. 1998; Moffat 1999).

The Ofpe/WN9 type WRs, and the high-luminosity B[e] stars have recently been implicated in the LBV phenomenon. The former have spectral properties intermediate between "Of" and "WN" (Bohannan & Walborn 1989). One of the prototypes of this class, R 127, underwent an LBV outburst in 1982 (Walborn 1982; Stahl et al. 1983; see discussion in Bohannan 1997). Similarly some B[e] stars have been described as having LBV-like outbursts. Var C, a well-known LBV in M 33, has a spectrum indistinguishable from B[e] stars: compare Fig. 8a of Massey et al. (1996) with Fig. 8 of Zickgraf et al. (1986). Do all B[e] stars undergo an LBV phase or not? Conti (1997) has provided an insightful review.

(2) What is the evolutionary connection between WN and WC stars? We expect only the highest mass stars become WCs, while stars of a wider range in mass become WNs. The changing proportion of WCs and WNs within the galaxies of the Local Group have been attributed to the expected dependence of these mass ranges on metallicity. However, the relative time spent in the WN and WC stages may also change with metallicity,

complicating the interpretation of such global measures drawn from mixed-age populations.

(3) Is there any evolutionary significance to the excitation subtypes? Both WN and WC stars are subdivided into numerical classes, or more coarsely into "early" (WNE, WCE) or "late" (WNL, WCL) based upon whether higher or lower excitation ions dominate. Recent modeling by Crowther (2000) suggests that the distinction between WNL and WNE is not actually due to temperature differences but primarily metal abundance. Armandroff & Massey (1991) and Massey & Johnson (1998) have argued that this true for the WC excitation classes based upon the metallicity of the regions where these stars are found.

If we knew the progenitor masses of LBVs and the various kinds of WRs we would have our answers to the above. However, here recourse to stellar evolution models fails us. Stellar evolutionary models show that a star's path in the HRD during core-He burning is strongly dependent upon the amount of mass-loss that has preceded this stage. Thus the nature of the LBV phenomenon becomes very important in understanding where WRs come from, as the amount of mass ejected by LBVs is large, but given the episodic nature of LBVs, hard to include in the evolutionary models. In addition, the locations of WRs and LBVs in the H-R diagram are highly uncertain. LBVs have pronounced UV-excesses and "pseudo-photospheres" (Humphreys & Davidson 1994). For WR stars, neither the effective temperatures nor bolometric corrections are established, as none of the standard assumptions of stellar atmospheres hold in the non-LTE, rapidly expanding, "clumpy" stellar winds where both the stellar continua and emission-lines arise (e.g., Conti 1988). While the WR subtypes represent some sort of excitation sequence in the stellar winds, the relationship, if any, to the effective temperature of the star remains unclear.

There has been recent success in modeling WR atmospheres, with convincing matches to the observed line profiles and stellar continua from the UV to the near-IR. These models have the potential for determining the bolometric luminosities and effective temperatures. The "standard WR model" (Hillier 1987, 1990) assumes a spherical geometry and homogeneity, and then iteratively solves the equations for statistical equilibrium and radiative equilibrium for an adopted velocity law, mass-loss rate, and chemical composition. (See also Hillier & Miller 1998, 1999.) Comparison with observations then permits tweaking of the parameters. Although the solutions may not be unique, good agreement is often achieved with observations, and in a series of papers, Crowther and collaborators have offered the "fundamental" parameters (effective temperatures, luminosities, chemical abundances, mass-loss rates, etc.) of WN stars obtained with this model (Crowther, Hillier & Smith 1995a, 1995b; Crowther, Smith, & Hillier 1995c; Crowther et al. 1995d; Crowther, Smith, & Willis 1995e; Crowther & Smith 1997; Bohannan & Crowther 1999).

Here we utilize a complementary, observational approach to the problem, one that can not only answer the question of the progenitor masses of LBVs and WRs, but also provide data on the BCs that can help constrain and evaluate the WR atmosphere models.

1.1. The Use of Cluster Turn-offs

A time-honored method of understanding the nature of evolved stars is to determine the turn-off luminosities in clusters containing such objects (Johnson & Sandage 1955; Schwarzschild 1958). This was first applied by Sandage (1953) to determine the masses of RR Lyrae stars in the globular clusters M 3 and M 92, with a result that was at variance with that given by theory (Sandage 1956). Similarly, the turn-off masses of intermediate-age open clusters were used by Anthony-Twarog (1982) to determine the progenitor masses of white dwarfs. However, it is one thing to apply this to clusters with ages of 10^{10} yr, as was done for the RR Lyrae stars, or to clusters whose ages are 2×10^7—7×10^8 yr, as was done for white dwarfs. Can we safely extend this to clusters whose ages are only of order 3–5$\times 10^6$ yr in order to determine the progenitor masses of WRs and LBVs?

When stars form in a cluster or association, stars of intermediate mass appear to form over a significant time span—perhaps over several million years (Hillenbrand et al. 1993; Massey & Hunter 1998). However, modern spectroscopic and photometric studies have shown that the massive stars tend to form in a highly coeval fashion. For instance, in their study of the stellar content of NGC 6611, Hillenbrand et al. (1993) found a *maximum* age spread of 1 Myr for the massive stars, and noted that the data were consistent with *no* discernible age spread. for all one could tell "the highest-mass stars could have all been born on a particular Tuesday." Similarly, the high mass stars in the R136 cluster have clearly formed over $\Delta\tau < 1$ Myr, given the large number of O3 V stars and the short duration that stars would have in this phase (Massey & Hunter 1998).

Such short time scales for star formation are consistent with recent studies by Elmegreen (1997, 2000a, 2000b), who argues that star formation takes place not over tens of crossing times but over one or two. For regions with large spatial extent (such as 100 pc diameter OB associations) star formation in the general region may occur over a prolonged time ($\leq$10 Myr). However, large OB associations can contain subgroups that have formed independently (Blaauw 1964), and are small enough so that a high degree of coevality ($< 1-2$ Myr) is expected. The stars from such a subgroup need not be spatially coincident. Rather, a star with a random motion of 10 km s^{-1} will have traveled 30 pc in just 3 Myr. Thus in an OB association we may find intermediate-mass stars which have formed from a number of subgroups over time, but massive stars which may have formed from a single subgroup and hence are coeval—even though these massive stars may now be spread out throughout the OB association. Or, it may be that massive stars of different ages are present, in which case the "turn-off mass" will not be relevant to the evolved object. We take an optimistic approach in our search for turn-off masses, but will insist that coevality be established empirically for the massive stars in the region in question.

For massive stars, the mass-luminosity relationship is much flatter than for solar-type stars ($L \sim M^{2.4}$ for 30 $\mathcal{M}_\odot$ and $L \sim M^{1.5}$ for 120 $\mathcal{M}_\odot$). As a result, the lifetimes of massive stars do not change as drastically with mass as one might expect. A 120 $\mathcal{M}_\odot$ will have a main-sequence lifetime of 2.6 Myr, a 60 $\mathcal{M}_\odot$ still will have a main-sequence lifetime of 3.5 Myr, and a 25 $\mathcal{M}_\odot$ star will have a main-sequence lifetime of 6.4 Myr. (These numbers are based on the $z = 0.02$ models of Schaller et al. 1992.)

Thus it should be possible to use clusters and OB associations to pin down the "minimum mass" of various unevolved massive stars. If the highest mass star still on the main-sequence is 60$\mathcal{M}_\odot$, and its associated stellar aggregate contains a WC-type WR star, then we might reasonably conclude that the progenitor mass of the WC star was at least 60 $\mathcal{M}_\odot$. Of course, if coevality does not hold, then this answer may be wrong—the WC star might have come from a 25 $\mathcal{M}_\odot$ that formed earlier. But were that the case, it would have to have formed *much* earlier—at least 3 Myr earlier, according to the lifetimes given above, and such an age spread should be readily apparent.

We can in principle also find the BCs from the cluster turn-offs. It is straightforward to determine the absolute visual magnitude of the WR, making some modest correction for the emission lines. Since massive stars evolve at nearly constant bolometric luminosity, we expect that the bolometric luminosity of the WR will be at least as great as the bolometric luminosity of the highest mass main-sequence object. With modern stellar models we can improve on this by making first-order correction for modest luminosity evolution.

We are, of course, not the first to have trod on this ground. Schild & Maeder (1984) attempted to provide links between the different WR subtypes using this sort of analysis of Galactic clusters, concluding that stars with masses as low as 18$\mathcal{M}_\odot$ became WN stars, while WC stars came from stars of 35$\mathcal{M}_\odot$ and higher, and proposing various evolutionary relationships between the various subtypes. Humphreys, Nichols, & Massey (1985) also used data drawn from the literature on (mostly the same) Galactic clusters, and found a considerably higher minimum mass for becoming a WR star (30 $\mathcal{M}_\odot$), with no difference between the masses required to become a WN or a WC. They were also the first to apply this method to determining the minimum bolometric corrections for WR stars, concluding that WNE stars have BCs < -5.5 mag, WNL stars have BCs < -3.5 mag, and WCs have BCs < -5.0 mag. (These BCs are considerably more negative than had been commonly assumed.) Smith, Meynet, & Mermilliod (1994) re-addressed the issue of BCs by analyzing the same data from the literature on what was also mostly the same clusters, finding BCs for WNs that were typically -4 mag (WNL) to -6 mag (WNE), and -4.5 for WCs, essentially unchanged from the Humphreys et al. findings.

There were problems, however, with these earlier studies. The most significant one was the reliance upon (the same) literature data for the spectral types of the main-sequence stars in these clusters and associations. Over the past decade we have examined the stellar content of numerous clusters and OB associations in the Milky Way, and invariably discovered stars of high mass that had been previously missed either due to reddening or simple oversight (Massey, Johnson, & DeGioia-Eastwood 1995a). A related problem is that some of the literature spectral types were "outdated" for the O-type stars, particularly for stars of type O7 and earlier, which would lead to an incorrect assignment of bolometric corrections and hence luminosities and masses. In addition, our understanding of massive star evolution has improved to the point where we can do a considerably better job in assigning masses, and in particular understand the errors associated with this procedure (see, for example, Massey 1998b). Another problem was that the spectral information was sufficiently sparse that no test of coevality could be applied to the cluster. In addition, poor photometry—often photographic—led to poor reddening corrections. And, finally, a significant limitation in these earlier studies was that all were restricted to the Milky Way. It would be most interesting to understand the origin of evolved massive stars as a function of metallicity; for this, extension to the Magellanic Clouds is a logical step.

We have attempted to rectify these problems by carrying out a modern analysis of OB associations containing WR and other evolved massive stars in galaxies of the Local Group, obtaining new spectroscopic and photometric data where warranted, and combining this with studies drawn form the recent literature. In this first paper we will determine the progenitor masses of WR and LBVs in 19 associations of the Magellanic Clouds. These two galaxies have abundances which are low compared to the solar neighborhood. In the next paper we will compare these to new results obtained for OB associations in our own Galaxy. In a third paper we will combine *HST* photometric and spectroscopic data with large-aperture ground-based studies to extend this work to the more distant members of the Local Group as an addition check on metallicity effects.

Throughout this paper we will assume the true distance modulus of the SMC is 18.9, and that of LMC is 18.5 (Westerlund 1997; van den Bergh 2000).

2. Sample Selection and Observing Strategy

In selecting this sample, we first compared the locations of known WRs and LBVs to that of the cataloged OB associations in the SMC and LMC. The probability of a chance supposition of a rare evolved object against one of these associations is, of course, low.

There are nine known WR stars in the SMC (Azzopardi & Breysacher 1979; Morgan, Vassiliadis, & Dopita 1991). Four of these are within three of the OB associations identified by Hodge (1985). We list these in Table 1. The WR star HD 5980 underwent an "LBV-like outburst" in 1994 (Barba et al. 1995). This star is located in NGC 346, which is included in our study. Three other SMC stars described as LBV-like in some way are R 40, which is not a member of any association: R 4, a B[e] star with "brightness variations typical for

LBVs" (Zickgraf et al. 1996), located in Hodge 12, but not included here, and AV 154 (aka S 18), another B[e] star tied to LBVs (Morris et al. 1996), located just outside of Hodge 35, also not included here. One other high luminosity B[e] star, R 50 (aka S 65=Sk 193), is listed by Zickgraf et al. (1986), but is well outside any OB association.

For the LMC, Breysacher (1981) cataloged 100 Wolf-Rayet stars; an occasional additional one has been found spectroscopically (e.g., Conti & Garmany 1983; Testor, Schild, & Lortet 1993), plus components of R 136 and other crowded clusters have been successfully resolved, which brought the total of known WR stars in the LMC to 134 (Breysacher, Azzopardi, & Testor 1999). As part of the present study, we discovered a new WR star, Sk-69° 194, located in LH 81. We compared the positions of WRs against the Lucke-Hodge OB associations (Lucke & Hodge 1970; Lucke 1972), using only those associations with "A1" classifications. Not all were included in the current study; we list in Table 1 the 16 associations that are, along with their WR stars.

Next we considered the LMC LBVs. Six are listed by Bohannan (1997): S Dor, R 71, R 127, HD 269582, R 110, and R 143. To this list we propose that R 85 be considered a seventh, based upon our discovery here of spectral variability (Section 3.1.1.1) and a recent characterization of its photometric variability (van Genderen, Sterken, & de Groot 1998; see also Stahl et al. 1984). Of these seven, S Dor and R 85 are in LH 41, which is included here, and R 143 is in LH 100, which is not. We argue later that one of the LH 85 stars may also be an LBV based upon its spectral similarity to other LBVs, but further monitoring is needed to establish variability; we include it in Table 1 as a previously unknown, high luminosity B[e] star. Three other "LBV candidates" are listed by Parker (1997) : R 99, S 61 (BE 153=Sk-67°266), and S 119 (HD 269687=Sk-69°175). Of these, only one is located near an OB association (R 99 near LH 49), and it is not included here. Finally, we also considered the location of the high luminosity B[e] stars (Table 1 of Lamers et al. 1998; see also Zickgraf et al. 1986, Zickgraf 1993, and in particular Fig. 10 in Gummersbach, Zickgraf, & Wolf 1995). Only S 134, is found in one of our regions (LH 104), although several are found in other OB associations; i.e., S 22 in LH 38 and R 82 in LH 35.

We have referred to all of these stellar aggregates as "OB associations", although the distinction between an OB association, and a bona-fide "cluster" young enough to contain O-type stars, is hard to quantify. The classical distinction, that clusters are gravitationally bound, is hard to establish, as it requires a census down to the low-mass components, plus detailed radial velocity studies. Semantics aside, our primary concern is to what degree these regions are coeval. Certainly most of the OB associations studied as part of our efforts to determine the IMFs are (Massey et al. 1995b). For the new ones studied here, we will establish the degree of coevality directly from the data.

Our observing strategy had similarities to our work that determined the initial mass functions in the LMC (e.g., Massey et al. 1989a, 1995b). It is possible to infer masses of main-sequence O- and B-type stars using their position in the physical H-R diagram ($\log T_{\rm eff}$ vs. M_{bol}) and comparing these with modern evolutionary models. There may be systematic problems with the masses thus inferred, although there is good agreement with the overlap of masses determined directly from spectroscopic binaries up to $25\mathcal{M}_\odot$ (Burkholder, Massey, & Morrell 1997), above which mass there is a scarcity of suitable data on binaries. Massey (1998b) discusses the errors in the inferred mass with temperature; since the BC is a steep function of the effective temperature, accurate knowledge of the latter is needed for this procedure to work. Sufficient accuracy cannot be achieved from photometry alone, but knowledge of the spectral type of the star yields adequate information in most cases. The sort of error bars associated with this can be found in Fig. 1(c) and 1(d) of Massey et al. (1995b). We will revisit this issue in Section 4.3.

For this project we considered relying simply on the photographic photometry or aperture photoelectric photometry that was available; e.g., Lucke (1972) or Azzopardi & Vigneau (1982), for the Large and Small Clouds respectively. After all, for the stars with spectroscopy (and hence accurate BC determinations) an error of 0.1 mag in the $B-V$ color will lead to a 0.3 mag error in M_V, given $A_V = 3.1 \times E(B-V)$. An error of 0.3 mag in M_V translates to an error of 15% in the derived mass (see details in Massey 1998b). (For comparison, if we were relying upon the colors alone and were dealing with a 0.1 mag uncertainty in $B-V$ we would have a 2 mag uncertainty in the BC, and thus a 0.4 dex uncertainty in the log of the mass (i.e., a factor of 2.5 uncertainty in the mass of the star).

For determining the IMF, it is necessary to pursue spectroscopy down the main-sequence until spectral-type of early B or later, after which good photometry provides as accurate information. Yet, in the case of determining the turn-off masses in principle we need to only ascertain that we have obtained spectra of the most massive unevolved object in the association. In a strictly coeval population with uniform reddening, this will be equivalent to knowing the spectral type of the visually brightest member. However, given finite photometric errors, slight non-coevality, reddening which is spatially variable across a cluster, the presence of other evolved supergiants (either members or field interlopers), and the need to demonstrate coevality, our initial aim was to obtain spectra for the six or seven visually brightest stars in each of these associations. Still, this is far fewer than what would be needed to construct the IMF.

Some of these associations had extensive CCD photometry and modern spectroscopy in the literature, and for these we constructed H-R diagrams and obtained a few additional spectra where warranted. In other cases, we already had existing unpublished CCD photometry (and in some cases even spectroscopy) that had been aimed at determining the IMF; the complete data for these associations, and the IMF analysis, will be published separately elsewhere. For the most part, though, we began with published photographic photometry, using this list to select the appropriate (brightest and bluest) stars for spectroscopy, and subsequently obtained new CCD *UBV* data in order to better correct for reddening. In all cases we examined the preliminary H-R diagrams and then obtained spectra of the few remaining interesting stars, as needed.

3. New Data

We list in Table 1 the source of the data we used, be they new or from the literature, or both. For the new data, we identify the year in which it was obtained.

For most of the associations (LMC) we began with the photographic iris photometry of Lucke (1972) or older sources, and obtained spectra of the brightest and bluest stars during a run on the CTIO 1.5-m telescope during 1996 Oct 27-31. Grating 58 was used in second order with a $CuSO_4$ blocking filter, yielding wavelength coverage from $\lambda3750$ to $\lambda5070$ with approximately 3Å (2.8 pixels) resolution. The Loral chip was formated to 500 $\times$ 1200 (15–μm) pixels. The slit was opened to 1.5 arcsec (85μm) and oriented EW, except for crowded regions, where the slit angle was adjusted and/or the slit narrowed. A typical S/N of 100 per 3Å spectral resolution element was achieved in a 5 min exposure at $V = 12$.

On the night following this run (i.e., 1996 Nov 1) we obtained *UBV* images of any OB associations without previous CCD data, using the Tektronix 2048$\times$2048 CCD imager on the CTIO 0.9-m. The field-of-view (FOV) was 13.5 arcmin by 13.5 arcmin, quite ample for the typical 3 arcminute diameter OB associations in our sample. Exposure times were usually 100 sec in U and 50 sec in each of B and V. The night was mostly photometric, although the alert observing assistant reported seeing a single cloud pass by part way through the night; later we will argue that this affected the U photometry of two regions but nothing else. Standard stars were observed at the beginning, middle, and end of the night, and reduced satisfactorily (0.01 mag rms residuals in U, B, and V in the fits to the solutions). Nevertheless, we treat the data as potentially non-photometric, comparing the derived reddening-free index $Q = (U - B) - 0.72 \times (B - V)$ with that expected on the basis of spectral type as a check, as described in Section 4. As we discussed above, our photometric requirements are in any event modest, given our extensive spectroscopy.

About half of the OB associations in our sample had previously been imaged with an RCA CCD on the CTIO 0.9-m in 1985 October by two of the present authors (PM and KDE). The full details of these data are given in Massey et al. (1989a). Although the FOV was only 2.5×4.0 arcmin in size, overlapping frames were taken when needed in order to include the whole of an OB association. The photometric integrity of these 1985 data is very high, as standard star observations were obtained over 10 photometric nights and used for precise determinations of zero-points and color-terms.

Similarly, some of the stars have previously unpublished spectroscopy obtained as part of our program to determine IMFs in the Clouds. Data obtained in 1989-1992 (Table 1) were taken on the CTIO 4-m telescope with the RC spectrograph. The details of these data were given by Massey et al. (1995b); here we will simply note that they were of comparable spectral resolution (3Å), and covered at least the wavelength region from Si λ4089 through He II λ4686. The S/N were typically 75 per 3Å spectral resolution element.

After our preliminary HRDs were constructed, we had two observing opportunities to obtain additional spectra where warranted. On 1999 Jan 3-7 we used the CTIO 4-m for significantly higher resolution and better S/N data. Grating KPGLD was used in second order with a $CuSO_4$ filter resulting in a resolution of 1Å (2.5 pixels) and a wavelength coverage of 3730Å to 4960Å using the Loral 1024×3100 (15 μm) CCD. The S/N obtained was typically 160 per 1Å resolution element. We obtained one final observation for this project on 1999 Oct 21 using the CTIO 1.5-m.

3.1. Analysis

3.1.1. Spectroscopy

We classified the spectra with reference to the Walborn & Fitzpatrick (1990) spectral atlas of O and B stars. Based upon our internal consistency and previous experience we expect that the spectral subtypes are determined to an accuracy of one subclass and one luminosity class (e.g., supergiant vs giant), except for the earliest O-type stars, for which there is little or no ambiguity in subclass. (See discussion in Massey et al. 1995a, 1995b.)

There is no metallicity dependence in classifying hot stars as to spectral subclass, as the primary spectral type (effective temperature) indicators are the relative strengths of different ionization states of the same ion; e.g., He I vs. He II for the O-type stars, and Si IV vs. Si III for the early B-type stars; however, it is our experience that the luminosity indicators are metallicity dependent, even for the O-type stars. This makes physical sense—in fact, it would be hard to see how this would fail to be the case—as the O-type luminosity indicators are primarily indicators of the strength of the stellar wind (i.e., He II emission vs. He II absorption). The B-type luminosity indicators rely upon how strong certain metal lines are relative to, say, He, and again we expect this to have a metallicity dependence. We therefore always checked the "MK" luminosity class with that expected on the basis of the absolute magnitudes, as described below; we note cases where we have adjusted the luminosity class based upon the absolute magnitudes.

All told, we classified slightly over 200 stars. We include our classification, as well as those from the literature, in the catalog we describe in Section 3.2. Here we will illustrate and comment on just a few of the more interesting spectra.

3.1.1.1. R 85. We propose that the luminous star R 85 in LH 41 be considered an LBV. Based upon their characteristic of its *photometric* variability, van Genderen et al. (1998) state that the star is "undoubtedly an active LBV." We show in Fig. 1 some of the *spectral* changes that have taken place in recent years; we agree with van Genderen et al.'s characterization. Feast, Thackeray, & Wesselink (1960) classify the star as "B5 Iae", and note the presence of Hβ emission, Hγ and Hδ absorption, as well as its photometric variability. Our 1996 spectra did not appear totally consistent with this description, as Mg II λ4481 was present but there was little or no He I λ4471; for a B5 star the latter should be somewhat stronger. We took a very high signal-to-noise spectrum with the CTIO 4-m in January 1999, and were surprised by the rapid and strong changes present since 1996; the newer spectrum shows the star to be hotter (based upon He I to Mg II) with much stronger lines. Dr. B. Bohannan was kind enough to make available a photographic spectrogram he obtained in 1985 on the Yale 1-m, along with a sensitometer exposure; there is very good agreement between his exposure, and what we obtained 11 years later. The recent change in the spectrum of R 85 suggests that further monitoring would be of interest. The photometry listed in Table 2 comes from the 1 Nov 1996 observation; e.g., $V = 10.53$, $B-V = 0.16$, and $U-B = -0.81$. In the 1985 data (28 Nov) the star was slightly brighter: $V = 10.44$, $B-V = 0.12$, and $U-B = -0.71$.

3.1.1.2. Newly Identified O3 Stars. As part of this investigation we came across a number of previously unrecognized O3 stars, stars whose effective temperatures are at the extreme of the spectral sequence of luminous stars. We show examples in Figs. 2 and 3.

First, let us consider the O3 supergiants (O3 If*) and giants [O3 III(f*)]. These evolved stars are still in the temperature regime covered by the O3 classification, and thus all such stars must be extremely massive. Walborn et al. (1999) classify the star LH90β-13 as O4 If+ on the basis of an FOS spectrum obtained with *HST*, but our higher signal-to-noise spectrum (with higher resolution) reveals N V $\lambda\lambda 4603, 19$ absorption; this, combined with the lack of He I makes this an O3 star (Fig. 2). The star ST5-31 in LH 101 was classified as O3 If* by Testor & Niemela (1998); our spectrum is in good agreement with that. We consider the star W16-8 in LH 64 an O3 III(f*) owing to the relative weakness of He II $\lambda 4686$, despite the extremely strong N IV $\lambda 4058$ emission and very strong N V $\lambda 4603, 19$, usually indicative of high luminosity; the absolute magnitude we derive in the next section is $M_V = -5.4$, consistent with this classification, and reminding us that slight abundance anomalies can mask as luminosity effects in early-type stars. A detailed atmospheric analysis of this star is in progress in collaboration with Rolf Kudritzki.

Among the O3 dwarfs (Fig. 3) we include ST2-22 (in LH 90). This star was previously recognized as an O3, but called a giant by Testor et al. (1993). The lack of emission at He II $\lambda 4686$, and the weakness of N IV λ 4058, suggest a lower luminosity class. We classify W28-23 in LH 81 as an O3 V((f)). The star ST5-27 in LH 101 was called an O4 V by Testor & Niemela (1998). The spectrum of this star is strongly contaminated by nebular emission lines. We tentatively adopt an O3 V((f)) spectral type, but our data are not inconsistent with the O4 V((f)) designation; we do not show the spectrum as the nebular lines makes casual comparisons difficult. Another star in LH 81, W28-5, appears to be intermediate between O3((f)) and O4 V((f)): the strength of He I $\lambda 4471$ relative to He II $\lambda 4542$ would argues that the star is a little bit later than O3, but there is N V $\lambda 4602, 19$ present on our high signal-to-noise spectra, and this has usually been taken as characteristic of O3s.

The presence of He I $\lambda 4471$ is easy to discern on the O3 stars in Fig. 3 because of the extraordinarily high S/N (160 per 1Å resolution element). The O3 class was introduced by Walborn (1971) to describe four stars in Carina which showed no He I $\lambda 4471$ on well-widened IIa-O emulsion spectrograms obtained at modest resolution (2Å). When finer-grain plates were used at higher resolution, He I $\lambda 4471$was detected with equivalent widths of 120-250 mÅ by Kudritzki (1980) and Simon et al. (1984) for three of the Carina stars. Here we find that He I λ4471 lines have equivalent widths of 75 mÅ in W28-23, and 105 mÅ in ST2-22, significantly smaller than that measured for the stars which first defined the class. Yet modern spectroscopy makes it possible to readily detect these lines.

3.1.1.3. Other O-type Stars. There are clearly other exceptions to the premise that N V $\lambda 4603, 19$ absorption is indicative of a luminous O3 star. In Fig. 4 we show the spectrum of ST5-52, a star in LH 101 classified by Testor & Niemela (1998) as O3 V. However, the strength of He I suggests a considerably later O5.5 type. It is easy to infer the basis for the Testor & Niemela classification of this star: our spectrum shows both NIV λ4058 emission and N V $\lambda 4603, 19$ absorption, typically assumed to be *only* characteristic of luminous O3 stars. One possibility is that this star is a spectrum binary, consisting of an O3 III(f*) plus a later O-type companion, which contributes the He I. However, we propose instead that this is a "nitrogen enhanced" star, and classify it as ON5.5V((f)). We prefer this latter explanation because we have identified another LMC star, not connected with the present study, whose He I to He II ratios are consistent with an O5 type, but which also shows N IV emission and N V absorption. Detailed atmospheric analysis is underway for both stars, pending *HST* data.

The star LH58-496 was classified as "O3-4 V" by Garmany, Massey, & Parker (1994). Our high S/N spectrum (Fig. 4) obtained with the CTIO 4-m shows a somewhat later spectral type, O5V((f)). In Fig. 4 we also show two other early-type dwarfs, an O5 V((f)) star and an O4 V((f)) star.

We illustrate a few newly discovered luminous O-type supergiants in Fig. 5. Examples shown here include supergiants from O4 through O8.

3.1.1.4. A Reconsideration of Br 58 as a WR star, and A Newly Discovered WR Star. The star Br 58 in LH 90, has long been recognized as a WN Wolf-Rayet star. Testor et al. (1993) classify it as WN6-7, while earlier work has classified it as WN5-6 (Conti & Massey 1989). We illustrate its spectrum in Fig. 6 from a new high-dispersion, high S/N observation. We note that our ground-based spectrum shows strong N V $\lambda 4603, 19$ *absorption*; this, plus the considerable strength of its absorption line spectrum, would tempt us to reclassify this as an extreme O3 If* star, i.e., O3If*/WN6. (See Fig. 3 in Massey & Hunter 1998.) These stars are believed to be young, H-burning hot stars whose very high luminosities result in sufficiently strong stellar winds to mimic the strong emission characteristic of a WR.

The star Sk$-69°$194=W28-10 in LH 81 is a newly discovered WR star, of type B0 I+WN. The spectroscopic discovery of another WR star in the LMC is not surprising, particularly given the weakness of the emission in this object. (The equivalent width of He II $\lambda 4686$ is -2Å, compared to typical -30Å for a very weak-lined WN star; presumably this is due to the continuum being dominated by the B0 I component.) We question below whether all B0 I+WN are truly binaries.

3.1.2. Photometry

UBV photometry is needed only (a) to determine accurate M_V values for the stars with spectra, and (b) to check that we obtained spectra for all of the likely "most massive unevolved star" candidates. In order to accomplish (a) we typically needed V and B-V data for half a dozen stars or so in each association, and to accomplish (b) we also required U-B, in order to construct a reddening-free index. Nevertheless, with modern techniques it proved just as easy to measure photometry for all stars on a frame, typically several *thousand* stars. At least we could then be assured that the brightest stars were well-measured, in the sense that their photometry was not contaminated by resolved neighbors.

We did this by fitting point-spread-functions (PSFs) using DAOPHOT implemented under IRAF. The 1996 CCD frames were measured by E.W., while the 1985 data were measured by P.M. The method used is similar to that described by Massey et al. (1989a) and we will give only a brief overview here. Automatic star-finding algorithms were used to identify stellar sources down to the "plate-limit" (typically 4σ above the noise). Aperture photometry through a small digital aperture (with a diameter corresponding roughly to the full-width at half-maximum of the stellar images) were then run in order to determine the local sky values for each star (determined from the modal value in an annulus surrounding each star) and to determine the instrumental magnitude to assign to the PSF stars. For each frame isolated, well-exposed stars were chosen to define the PSF. This PSF was then simultaneously fit to all of the stars whose brightnesses could possibly overlap. In regions of nebulosity, the sky value was also fit separately; otherwise, an average sky value was adopted for all the stars in a given fitting exercise. A frame in which the fitted PSFs had been subtracted was then examined to see how well the PSF matched and to look (by eye) for any stars that had been buried in the brightness of other stars. In addition, the U, B, and V frames were blinked along with the fitted xy centers to make sure there was consistency. Missing stars were added back into the star list and a final run was made on each of the three colors. Aperture corrections were then determined for each frame in order to correct the instrument zero-point (based upon the small digital aperture) to the large apertures used to measure the standard stars. These instrumental magnitudes were then transformed to the standard system. In the case of the 1985 RCA CCD data there were often overlapping frames involved in covering a region, and the final photometry was combined to produce a single star list, with stars with multiple entries averaged.

One region, Lucke-Hodge 41, was common to both data sets, and thus served as an end-to-end independent check on the final, transformed photometry. If we consider the twenty brightest stars (in V) we find a mean difference (new minus old data set) of +0.015 mag in V, +0.011 mag in $U-B$, and +0.014 in $B-V$, with sample standard deviations of 0.06 mag, 0.02 mag, and 0.04 mag, respectively. If two outliers are removed from the V data, and one from the $U-B$ data, the mean differences become +0.002 mag and +0.001 mag, respectively with standard deviations of 0.03 mag and 0.04 mag. This agreement is excellent, and suggests that no systematic differences exist between the two data sets over the magnitude and color ranges of interest.

3.2. The Catalog

We list in Table 2 the brightest stars in each of the 14 associations for which we have new photometry; existing and new spectral types are also given. We include all stars of magnitudes $V = 15$ or brighter; in several cases we extended this to fainter magnitudes to include additional stars with spectral types or, in the case of NGC 602c, to include at least 10 stars. For two of the associations (LH 58 and LH 101) we reply upon cited studies (cf., Table 1) but have a few new spectral types; we include these in Table 2. (For three addition associations, NGC 346, LH 9, and LH 47, we reply purely on the cited works in Table 1.)

In listing the stars we make use of published names where available finding charts exist, although the celestial coordinates given in Table 2 should be of sufficient accuracy to remove the need for finding charts. For the LMC, we have kept with the star numbering given in the finding charts of Lucke (1972), with additional stars given designations of 1000+ so as to avoid confusion. The exceptions are those associations with modern CCD studies, where we have kept with the numbering scheme employed by the authors. In a few cases the associations contained stars that were saturated on our CCDs (typically $V < 10$); we include photometry of these stars from the literature. We describe below details related to each association, making reference to the results obtained in subsequent sections.

3.2.1. Descriptions of Individual Associations

NGC 346: We rely on the CCD photometry and spectroscopy of Massey, Parker, & Garmany (1989b). The imaging data had their source in the same observing run as the 1985 imaging used for many of the other associations studied here. Four of the brightest stars were also subjected to detailed analysis by Kudritzki et al. (1989). Reanalysis of these stars by Puls et al. (1996) was used in the spectral type to effective temperature calibration of Vacca, Garmany, & Shull (1996), which we adopt in the next section; we note here that despite the different methodology involved, the masses determined by Puls et al. for these stars are in good agreement with those we compute in the following sections. The visually brightest star is HD 5980, the WN3+abs Wolf-Rayet that underwent an LBV-like outburst. The second brightest star is the O7If star Sk 80. More than a magnitude fainter visually are the very early O-type stars first found by Walborn (1978), Walborn & Blades (1986), and Niemela, Marraco, & Cabanne (1986).

Hodge 53: Our photometry here is a comprehensive mosaic of several CCD frames and extensive spectroscopy obtained with the goal of determining the IMF. However, the the region is not condensed, and there are several stars of type A-F and later, some of which are apparently foreground dwarfs or giants, and others which are SMC supergiants. Our spectrum of AV 331 shows it to be an SMC member of type A2 I, based both on its radial velocity, appearance of the hydrogen lines, and the strength of Fe II λ4233 (see Jaschek & Jascheck 1990, Fig 10.2). However, our spectrum of AV 339a shows it to be an F2 foreground star, probably a dwarf, based both on its radial velocity and lack of luminosity-sensitive Sr II λ4077. A fainter star, h53-144, is an A8 foreground dwarf. We lack spectra for the other yellow stars, and so we cannot comment further on their membership. Our spectroscopy has also identified a double-lined spectroscopic binary (O4 V+O6.5 V) which is among the most bolometric luminous members. When we construct the HRD, we will consider that each of the two components contributes equally to the visual flux, consistent with the appearance of our double-lined spectrum, and the expected M_Vs of stars of these spectral types. The visually brightest member is the WR binary AV 332=Sk 108=R 31=AB 6 (WN3+O6.5) with a 6.54 day orbit (Moffat 1982, 1988; Hutchings et al. 1984; Hutchings, Bianchi, & Morris 1993). Hutchings et al. (1984) argue convincingly that the O-type companion dominates the visual flux by a factor of 10 to 1 (making it of luminosity class "I"), and that its location in the HRD suggests an initial mass of $70 - 80\mathcal{M}_{\odot}$, consistent too with its Keplerian mass. Our analysis will yield a very similar value. The other WR member, AV 336a=AB 7, is quite a bit fainter. The WR component is likely a WN3 (Moffat 1988), although all that is certain is that it is earlier than WN7 (Conti, Massey, & Garmany 1989). An O-type absorption spectrum is also seen. Recent work by Niemela (1999) suggests a 19.6 day period.

NGC 602c: NGC 602 is located in the wing of the SMC; the region was studied by Westerlund (1964), who identified three sub-components. Components "a" and "b" are adjacent and are immersed in nebulosity known as N90 (Henize 1956); component "a" is also known as Lindsey 105 (Lindsey 1958). Here we are concerned with the third component, "c", which is an isolated condensation with little nebular emission. It was designated as a separate association both by Lindsey (1958) and Hodge (1985), and is known as "Lindsey 107", and "Hodge 69". (See Plate 5 and Figure 1 in Westerlund 1964.) We obtained new CCD photometry of NGC 602c. Its visually brightest star is the WR star AB 8, the only WC star known in the SMC. It has enhanced oxygen, and was classified by Conti et al. (1989) as "WO4 + abs". (Crowther, De Marco, & Barlow 1998 instead call the WR component "WO3".) A new spectrum of the star obtained as part of the present program suggests that the absorption spectrum is O4 V. Moffat, Niemela, & Marraco (1990) present an orbit for this system with a period of 16.644 days. They propose spectral types of WO4+O4 V, with which we concur, although Kingsburgh, Barlow, & Storey (1995) suggest a somewhat later type for the O star.

LH5: Our photometry and spectroscopy are the first modern study of this association. The visually brightest star is Sk $-69°30$, a G-type supergiant according to Feast et al. (1960), with the next brightest star an O9 I. The WR star, Br4, was described as "WN2" by Conti & Massey (1989), as no N lines are visible, similar to the WN2 Galactic star HD 6327. Like that star, Br 4 has a faint absolute magnitude. We will find in subsequent sections that the star has a normal bolometric luminosity, and that its faintness is presumably due to a very high temperature, which shifts its light into the unobserved UV. In constructing our HRD we find that the G5 Ia star Sk $-69°$ 30 is coeval with the rest of the massive stars.

LH9: This association was studied in detail by Parker et al. (1992), using the same 1985 imaging data and calibration that we employ here for many of the other associations. The central object, HD 32228, was clearly an unresolved cluster of many early-type stars, with a composite WC+O spectral type. The region was recently examined using *HST* by Walborn et al. (1999), and we adopt their photometry and spectroscopy here, ignoring the region outside of the central 30 arcsec covered by the PC frame of WFPC2. Although they were able to spectroscopically observe the WC component separately from its close neighbors for the first time, their spectral classification of WC4 is based upon only a spectrum in the blue, which lacks the crucial classification lines O V $\lambda5592$, C III $\lambda5696$ and C IV $\lambda5812$ (e.g., Smith 1968a; van der Hucht et al. 1981). Walborn (1977) had earlier classified the WR star as WC5, but this was also based upon a blue spectrogram. Smith (1968b) called the star WC5, but this was before the earlier WC4 subclass was introduced. Breysacher et al. (1999) cite a speckle study by Schertl et al. (1995) for the spectral type, but no spectrum was actually taken as part of that study. We adopt WC4 as the spectral type, but note here that the type is uncertain. The visually brightest stars in the LH 9 association are late-O supergiants (O9 I and O8.5 I).

LH12: Ours is the the first modern study of this association. It contains the WC4 star Br 10. The visually brightest stars are B-type supergiants, although our study has revealed a very early O-type star, with type O4 V(f). To the extent that the association is coeval, the B-type supergiants evolved from stars of spectral subtype O4 V or even earlier.

LH31: This association contains two Wolf-Rayet stars, Br 16 classified by Conti & Massey (1989) as WN2.5. A second WR star has been recently discovered by Morgan & Good (1985), who classify the star as WC5+O. This star is BAT99-20 in the catalog of Breysacher et al. (1999), whose finding chart puts the star centrally located in the association boundary shown by Lucke (1972). Nebulosity prevented Lucke from photographic photometry of any by the brightest few stars. The visually brightest stars include a B1 III, an O6 I(f), and two yellow stars. One brighter of these, which we call LH31-1002, is apparently an LMC F2 supergiant, based both upon our measured radial velocity and strong Sr II λ4077 (see Jaschek & Jaschek 1990). The other is clearly a late F-type foreground dwarf, based upon its radial velocity and its lack of Sr II.

LH39: The cluster was examined by Schild (1987), and again by Heydari-Malayeri et al. (1997). We obtained new photometry and a few additional spectral types. The association contains one of the rare Ofpe/WN9 stars, Br 18=Sk$-69°$79. Ardeberg et al. (1972) list the star Sk$-69°$80 as having a spectral type of F2 Ia; however, Schild (1987) suggests a type of B8: I. Our photometry is consistent with something intermediate between these two, and we will use its photometry to place it in the HR diagram. (The radial velocity of Ardeberg et al. does confirm it is an LMC member.) We will find that two A supergiants classified by Schild (1987) appear to be much older than the rest of the cluster. We have independent spectroscopy for one of these, LH39-22, and confirm Schild's type.

LH41: This association contains S Doradus, the prototype LBV, and the visually brightest star in the cluster. The second brightest star, R 85=Sk-69−69°92 we propose as an LBV, based upon its spectral and photometric variability, as discussed earlier in Section 3.1.1.1. The third brightest star is the Wolf-Rayet star Br 21, classified by Conti & Massey (1989) as B1Ia + WN3. The star LH41-4 is of M-type, but we lack the radial velocity information that would ascertain whether this is an M supergiant or foreground dwarf. There are two lower luminosity but bona fide A-type supergiants, and an F5 supergiant. The latter has been confirmed based upon our radial velocity and the strength of Sr II λ4077. (It is also an excellent match to the F5Iab star HD 9973 shown in the Jacoby, Hunter, & Christian 1984 atlas.) Ours is the first modern study of this association.

LH43: The visually brightest star is an early M-type, but again we lack the proper radial velocity information to ascertain whether this is an LMC member or not. The second brightest star is a newly discovered O4 If star. The WR star Br23 is classified WN3.

LH47: This association was studied by Oey & Massey (1995) and Will, Bomans & Dieball (1997). We adopt the photometry and spectroscopy of the former, who obtained spectral types for all the brighter components, primarily of early to mid O-type. Oey & Massey (1995) suggest that there are two ages for the stars in the LH47/48 region: stars interior to the DEM 152 superbubble have an older age than stars in rim of the bubble. The WR star and other massive stars of interest are on the exterior, and we will restrict our analysis to those. In agreement with Will et al. we find no difference between the photometric Q and that expected on the basis of spectroscopy; we cannot comment on their assertion that field-to-field differences exist in the individual $B-V$ and $U-B$ colors at the 0.15 mag level, other than to note our value for the reddening appears to be reasonable.

LH58: This association was recently studied by Garmany et al. (1994). It contains three WR stars, Br 32 (WC4+abs), Br 33 (WN3+abs), and Br 34 (B3I+WN3). The latter is the visually brightest star. We did obtain a spectrum of the earliest-type star in the association, reclassifying it from O3-4 V to O5.5 V((f)), as described earlier (Section 3.1.1.3). We note that LH58-473 as B0.5V must be a giant based upon its M_V.

LH64: This association was studied by Westerlund (1961) as well as by Lucke (1972). Ours is the first modern study. The three visually brightest stars have colors characteristic of mid-to-late type stars, presumably foreground, although spectroscopy is needed to determine if they are supergiants. The WR star Br 39 was not classified by Conti & Massey (1989), but was called WN3 by Breysacher (1981).

LH81: Also studied by Westerlund (1961) and Lucke (1972), ours is the first CCD study of this interesting region. It contains three WR stars: the WC4 star Br 50 (classified by Conti & Massey (1989), the WN4+OB star Br 53 (classified by Breysacher 1981), and Sk$-69°$194, discovered as a WR star here (B0I+WN). The visually brightest star is a foreground G dwarf. We identify two very early-type stars in the association, W28-23, a O3 V((f)) star, and W28-5. As discussed in Section 3.1.1.2, we classify the latter as O4 V((f)) based upon its He I to He II strengths, but our very high S/N spectrum shows the definite presence of N V $\lambda4603, 19$ absorption lines, previously associated only with O3 stars. Possibly an intermediate type (O3.5) would be warranted, but we leave that until we have been able to complete a detailed analysis of this star.

LH85: We identify the star LH85-10 as a newly discovered B[e]. Our study is the first since Westerlund (1961) and Lucke (1972). The association also contains the WR star Br 63, classified as WN4.5 (Breysacher et al. 1999). Westerlund (1961) treated this association and the neighboring LH 89 as one unit; we treat them separately here, following Lucke (1972), although the ages and cut-off masses we derive will prove to be essentially the same. The earliest spectral type we find in LH 85 is B0.5.

LH89: A section of LH89 was included in the study by Schild & Testor (1992) of stars in the general 30 Doradus region (their "zone 3"), in addition to the Westerlund (1961) and Lucke (1972) studies. We have used their spectral types as a supplement to our own, but use our own CCD photometry. The association contains Br6 (WN4) and Br 64=BE 381, the archetype of Ofpe/WN9 stars. The visually brightest stars are three tenth magnitude stars of intermediate color; radial velocities of the two brightest demonstrate that they are LMC members (Ardenberg et al. 1972). Our spectrum of the third shows it is a foreground F8 dwarf, based both on its radial velocity and the weakness of high-luminosity features in the spectrum, emphasizing once again the need for spectroscopy in determining membership of even bright stars in the Clouds. We will find that the two confirmed A-F supergiants turn out to be coeval with the rest of the association members.

LH90: Photometry of the LH 90 region was published by Schild & Testor (1992), who refer to the region as "Zone 2", and provide a finding chart in their Figure 3. (Only stars 2-33, 2-34, and and 2-45 fall outside the association boundary shown by Lucke 1972.) There are three clumps of stars, designated as "clusters" α, β, and δ by Loret & Testor (1984). The region was re-examined by Testor et al. (1993), who provided new photometric and spectroscopic data on knots α and β. Clusters β and δ were also studied by Heydari-Malayeri et al. (1993). Recently, Walborn et al. (1999) were largely successful in further unraveling the β knot of stars using WFPC-1 images and FOS spectroscopy with *HST*. (They refer to β alternatively as "NGC 2044 West" and "HDE 269828".) To this, we add our own *UBV* photometry and spectroscopy. We note that a comparison of the high resolution image of Testor et al. (his Fig. 1b) with that of Walborn et al. (Fig. 5) suggest that ground-based work actually did a remarkably good job of resolving multiple components in cluster β. The stars designated "TSWR2" and "TSWR1" are multiple, but the others are actually well resolved with 1" resolution. The components found independently by our PSF-fitting are an exact match to those identified by Testor et al. The most interesting star is the one Testor et al. identify as "6" in cluster β; this is the star labeled “9” by Heydari-Malayeri et al., and split into two components (“9A” and “9B”) by Walborn et al., although 9B is 1.5 mag fainter than 9A and hence the composite spectrum we obtained from the ground is a good representation of star 9A. We have noted earlier (Section 3.1.1.2) that the star $\beta - 13$ is probably better considered an O3 If* star rather than the O4If+ used by Walborn et al.

In our analysis of this region we will make use of our new ground-based data, but defer to the *HST* data of Walborn et al. for stars for the the group of stars called “TSWR1” (or β-6) by Testor et al., which is the star identified as “5” by Heydari-Malayeri et al., split into multiple components by Walborn et al. (1999). Our ground-based (composite) spectrum would have resulted in a “B0I+WN” designation, but the *HST* work clearly shows that these are separate stars, in accord with Testor et al.’s finding. One wonders if other “BI+WN” systems might not be similarly resolved. We also note the need for a high-resolution study of the δ knot in this interesting region.

In addition to the WN4 component of “TSWR1”, the association contains many other WRs: Br 56 (WN6), Br 57 (WN7), Br 58 (WN5-6), and Br 65 (WN7), all of fairly late type for the LMC, plus the WC4 star Br 62. The classifications are from Conti & Massey (1989), except for that of Br 65, which is from Breysacher (1981). Earlier (Section 3.1.1.4) we suggest that Br 58 may be better classified as O3If*/WN6.

In analyzing this cluster in Section 4.3, we find that the β subclump is no more coeval than the association as a whole, as witness the fact that both a B0 I star of modest luminosity cohabits with an O3 star of high luminosity. There is a significant range of ages.

LH101: This region has recent CCD photometry and spectroscopy by Testor & Niemela (1998). To this, we obtained our own spectra for three of the stars, as discussed in Section 3.1.1. We find that ST5-27 is an O3V((f)), as indicated both by the lack of He I and the weak presence of N V $\lambda4609, 19$ absorption; the star was classified as O4 V by Testor &

Niemela. We confirm that their star ST5-31 is indeed an O3If. And, we reclassify ST5-52 as an ON5.5V((f)) star, rather than O3 V (Section 3.1.1.3). The association contains Br 91, another of the rare Ofpe/WN9 objects.

LH104: This association was also studied by Testor & Niemela (1998). We have obtained new CCD photometry, as well as additional spectroscopy. The association contains three WRs, all of which are spectrum binaries as described by Testor & Niemela: Br 94 (WC5+O7), Br 95 (WN3+O7), and Br 95a (WC5+O6). The visually brightest star is the B[e] star, S 134 (Zickgraf 1993). We note that one of the visually brighter stars is an M star, confirmed by Testor & Niemela as a supergiant on the basis of its radial velocity; this agrees with the conclusion of Massey & Johnson (1998) that WRs and M supergiants are sometimes found in the same associations, contrary to the prevailing wisdom.

4. Construction of HRDs: Coevality and Uncovering the Most Massive Stars

In order to identify the most massive stars, we construct "physical" H-R diagrams ($\log T_{\rm eff}$ vs. M_{bol}) for comparison with the theoretical evolutionary tracks. These tracks will allow us to test for coevality, and determine the masses for the highest mass unevolved (H-burning) stars in these associations. First, we must correct the observed photometry for reddening, and second to convert the data (spectral types and photometry) to effective temperatures and bolometric magnitudes. Next we will construct the HRDs and uncover the masses of the most massive stars.

4.1. Corrections for Reddening and Testing the Reddening-free Index Q

Our first step in constructing HRDs is to determine the reddening corrections for each region. For stars with spectral types, we adopt the intrinsic colors of FitzGerald (1970) as a function of spectral type and compute the color excess $E(B-V)$ directly. Occasionally even a star with a spectral classification has a reddening which differs substantially from the other members in a region, and so we've chosen to constrain the reddening to the range indicated by the majority of stars for which there are spectral types. We list in Table 3 the average color excess $\overline{E(B-V)}$ and ranges of $E(B-V)$ we adopt for each of the 19 associations. (For consistency, we re-derived reddenings even for the associations with values already in the literature.)

Although we obtained spectral types for most of the bright stars in each association, there are some stars for which we have only photometry. Rather than de-redden these using $\overline{E(B-V)}$ we employed a relationship between Q and $(B-V)_o$ to de-redden each star individually, using the star's photometry and $\overline{E(B-V)}$ as a gauge of whether the star's intrinsic colors were sufficiently blue for this method to work. We found that for stars with $Q < -0.2$ for $(B-V)_o \approx (B-V) - \overline{E(B-V)} = -0.06$ we could de-redden star by star; for stars with intrinsic colors redder than this amount, we adopted the average reddening. We did further constrain the reddening to the range determined by the majority of stars with spectral types in a region.

Since our earlier work (Massey et al. 1989b, 1995b) it has become clear that the intrinsic colors as a function of spectral type or effective temperatures are not extremely well know, particularly for the early B supergiants, and we have therefore computed new relationships based Q and $(B-V)_o$ (and the intrinsic colors and effective temperatures) using the Kurucz (1992) ATLAS9 models, using a metallicity of 0.8 times solar, a compromise between SMC, LMC, and (local) Galactic abundances. We find

$$(B-V)_o = -0.005 + 0.317 \times Q$$

regardless of luminosity class.

Construction of the reddening-free index Q for the stars with spectral type allows an independent check upon the accuracy of the photometry: is there good agreement between the observed Q and that Q expected on the basis of the intrinsic colors for that spectral type? We determine if there is a statistically significant shift in Q for all the stars for which we have spectral types in each association. In general we find deviations in Q within 1σ of 0.0. The only exceptions for our new photometry are LH 43, for which we adopt a shift $\Delta Q = -0.13$, and LH 64, for which we adopt a shift $\Delta Q = -0.15$ (i.e., in both cases the photometric Q must be made more negative to agree with the expectations of the spectroscopy). The two regions were imaged within a few minutes of each other during the 1996 night at about the same time that the observing assistant reported seeing an isolated cloud. Interestingly, the reddening values we found for these two regions are each quite reasonable, suggesting that it might have been only U which was affected in the two fields. Inspection of the observing logs confirms that the U exposure of LH 43 was observed back-to-back with the U exposure of LH 64. The next regions observed, LH85/89, appears to have no significant photometric problems. We see no problems with any of the 1985 data, either published or new in this paper. We do find a shift of $\Delta Q = -0.11$ for the LH 101 photometry published by Testor & Niemela (1998). Although the large scatter (0.08 mag) makes this result marginal in significance, and nearly all the stars of interest to us have spectral types, we still apply this correction to their photometry.

The WFPC2 photometry of LH 9 ("HD 32228") by Walborn et al. (1999) also shows a systematic shift in Q, with $\Delta Q = -0.07 \pm 0.01$(s.d.m.) mag. Presumably this shift is an artifact of their reduction procedure. This shift is larger than any of the ground-based UBV data reported here, other than the cases noted above, and so it is unlikely due to any problems with the spectral-class to Q relationship we adopt. We did not apply any correction to their data as we used only the stars with spectral types in constructing the HRD, although this could have some minor effect on the absolute magnitudes (0.2 mag) and hence masses we determine if the problem is in $B - V$ rather than in $U - B$.

4.2. Conversion to $\log T_{\rm eff}$ and Bolometric Luminosity

The final step in constructing the HRDs is to use the data to determine the effective temperature and bolometric luminosity of each star.

For stars with spectral types, we begin by adopting the spectral type to effective temperature scale given by Vacca et al. (1996) for O-type stars, based as it is on the results of modern hot-star models. This will yield results that are somewhat hotter and, thus, somewhat more luminous and massive than the older effective temperature scale of Chlebowski & Garmany (1991), say, or that of Conti (1973). For the early B stars we were faced with a dilemma. As discussed by Massey et al. (1995a) there is a discontinuity in the effective temperature scales of hot stars corresponding to roughly where the modern work of Conti (1973) ended (i.e., O9.5) and earlier works took over. In order to smooth the transition, we have adopted the effective temperatures of B0.5-B1 dwarfs and giants as given in Table 3-4 of Conti (1988), as those are in excellent agreement both with what we expect on the basis of the intrinsic colors from the model atmospheres, and with the spectral analysis of Kilian (1992). For B1.5 and B2 dwarfs and giants, we compromised between the latter two. For the B-type supergiants, we made use of the effective temperatures suggested by Conti (1988), the recent spectroscopic analysis of two early B supergiants by McErlean, Lennon & Dufton (1998), a comparison of the intrinsic colors listed by FitzGerald (1970) with those of the Kurucz model atmospheres, and the effective temperature scale given by Humprheys & McElroy (1984). In the past we have relied exclusively on the latter; we note here though that this disagrees with the more recent analysis by 0.1 dex from B1 I through B5 I. It is clear that a consistent effective temperature scale that extends from O through the B-type stars is currently lacking, and the compromise we use here is only a stop-gap until a comprehensive study can be done.

For stars with photometry alone, we rely upon a relationship between the reddening-free parameter Q and $\log T_{\rm eff}$ determined from the Kurucz models; this relationship is given in Table 4, and is appropriate for intrinsically blue stars [($Q < -0.6$ and either $(B-V)_o < 0.00$ or $(U-B)_o < -0.6$]. For redder stars, we use a relationship between $(B-V)_o$ and $\log T_{\rm eff}$ also given in Table 4, based upon the Kurucz models. The latter relationship need not be of high accuracy, as the BC becomes a less steep function of $\log T_{\rm eff}$.

The bolometric correction (BC) is a function primarily of effective temperature with little dependence on $\log g$; we adopt the approximation $BC = 27.66 - 6.84 \times \log T_{\rm eff}$ appropriate to hot stars ($\log T_{\rm eff} > 4.2$) given by Vacca et al. (1996). For the cooler supergiants we find discrepancies between the BCs listed by Humphreys & McElroy (1984) and the corresponding effective temperatures when compared to the Kurucz models; we adopt the relationship given in Table 4 based upon a fit of the BCs with $\log T_{\rm eff}$ based upon the Kurucz models.

We show the resulting HRDs in Fig 7. In these figures, we have indicated the stars with spectral types by filled circles, and those stars with only photometry with open circles. Crosses represent stars with only photometry whose placement in the HRD are uncertain for one reason or another: either their transformations failed because of unrealistic colors, resulting in superfluously high effective temperatures and locations to the left of the ZAMS, or else their colors are too red to allow us to determine their reddening using Q, or the derived reddening falls outside the range we adopted on the basis of our spectroscopy. We also mark with an asterisk stars with spectral types but whose location is uncertain, such as the components of double-lined binaries. We include in these diagrams the evolutionary tracks of Schaerer et al. (1993) computed at $z = 0.008$ (appropriate for the LMC), and the tracks of Schaller et al. (1992) at $z = 0.001$, similar to the $z = 0.002$ of the SMC.

We also show isochrones corresponding to ages of 2, 4, 6, 8, and 10 Myr (dashed curves), which we computed using a program kindly provided by Georges Meynet.

4.3. Identification of the Most Massive Stars, and the Limits of Coevality

Using the results of our calculations in the previous section, we can now identify the mass of the highest mass unevolved (H-burning) star in each association. We list the derived quantities ($\log T_{\rm eff}$, $M_{\rm bol}$, mass, age) for the highest mass stars in Table 5.

For associations that are strictly coeval, we expect that the stars in the HRD will follow a single isochrone, and in that case the highest mass would correspond to a "turn-off" mass and we could be confident that any evolved members of these associations were descended from stars with masses greater than this value. Alas, the HRDs of Fig. 7 do not for the most part yield such an unambiguous picture. In all cases there is some spread across isochrones. If real, such spreads would tell us that the massive stars formed over some period of time.

How significant are these age spreads? We can answer this quantitatively by considering the errors associated with the placement of stars in the HRD. Let us first consider the *systematic* errors. In Fig. 8(a) we show the location of the spectral type calibration data in the HRD. The huge gap among the supergiants (upper-most string of points) corresponds to the difference in the adopted effective temperature of a B5 I and a B8 I star, which is a realistic uncertainty in spectral classification. Smaller gaps likewise correspond to differences of a single spectral type. We have adopted an absolute magnitude corresponding to each type; of course, our stars, with M_V computed from the photometry, will fall both above and below the points shown. It is instructive to see the systematic deviation of these stars from the ZAMS as one approaches cooler temperatures among the dwarfs. By log $\mathrm{T_{eff}} = 4.2$ the locations of the dwarfs are nearly coincident with the *terminal* main-sequence, as indicated by the first switch-back in the tracks. In this region the isochrones are tightly spaced, and a large error in the age spread would result if we compared the ages of a high mass luminosity class "V" stars with one of lower mass; for this reason we should exclude stars below $20\mathcal{M}_\odot$ unless they are of high *visual* luminosity, such as an A-type supergiant.

We note that this progression away from the ZAMS is intrinsic to the spectral type to $\log T_{\rm eff}$ calibration we've adopted and/or the absolute visual magnitude scale we've used for the purposes of this illustration. Transformations to effective temperatures on the basis of *colors* are usually often based on the use of spectral types as an intermediate step, rather than going directly from model atmosphere colors to effective temperatures. In these cases, the apparent presence of stars to the right of the ZAMS might be misconstrued as evidence of pre-main-sequence objects. We emphasize the need for spectroscopic followups to establish the authenticity of such discoveries.

Next, let us consider the *random* errors caused by misclassifying stars by a single spectral type and/or major luminosity class; i.e., calling a star an "O8 III" when in fact it is an "O9 I". (The absolute visual magnitudes of these two subclasses overlap, and so our photometry would pose no warning.) We would overestimate the star's luminosity by 0.1 mag simply by assuming a slightly too negative $(B-V)_o$, which will lead to too large a value for A_V. More significant, however, is the fact that we will overestimate the star's effective temperature by 0.05 dex, and thus overestimate the star's bolometric correction by 0.4 mag, for a net error of 0.5 mag. The age we calculate might be 3.80 Myr (6.58 dex) if the actual age were 5.25 Myr (6.72 dex). We expect misclassification by a single spectral subtype to be common. The size of the errors we make will depend of course upon the spectral type. We show in Fig. 8(b) the errors associated with misclassification of a star by one spectral type and/or luminosity class. (We have not included in this figure the modest addition error caused by the change in reddening adopted; this will increase these errors.)

Given this discussion, we can ask the question: what fraction of stars of $20\mathcal{M}_\odot$ and above, and lower-mass supergiants, are in fact consistent with some median age for the association? We assume here that our error in spectral sub-typing is only 1 subtype, except for uncertain cases. We compute the youngest and oldest ages of each star associated with such a misclassification; if the cluster's median age falls within this range, we consider that the star is coeval with the rest of the cluster. We use only the stars for which there are spectral information, as the errors in the HRD are much greater for stars with only photometry. (Compare Figures 1c and 1d of Massey et al. 1995b.) We list the fraction of stars that we find to be coeval in Table 6, along with the median ages of the clusters.

Even for the clusters that have a large percentage of stars whose ages are within 1σ of the median cluster age, we might well ask the question if the ages of the highest mass stars are in accord with this value. After all, we know that in some clusters intermediate mass stars form over some period of time (several million years), with the highest mass stars forming over a shorter time, e.g., NGC 6611 (Hillenbrand et al. 1993) and R136 (Massey & Hunter 1998). We include the median age of the three highest mass stars in Table 6.

Inspection of the HRDs in Fig. 7, and of the numbers in Table 6, suggests that there is a natural division, and that some of these associations are highly coeval while the coevality of the others are more questionable. If the match between the median cluster age and the age of the 3 highest mass stars is good (< 0.2 dex, comparable to the individual errors), and a large percentage of stars ($> 80\%$) lie within 1σ of the median cluster age, we consider that degree of coevality is high. Clusters that fail to meet one or the other criterion we consider the degree of coevality questionable. We consider the coevality high in 11 of our clusters, and questionable in four. We regard the other five associations as non-coeval. This could be evidence that massive stars have formed over a prolonged period, possibly with several subgroups of different ages contributing, but it may also be simply due to line-of-sight contamination within the Magellanic Clouds.

The age structure of the LH 47/48 was discussed by Oey & Massey (1995); as mentioned earlier, we restrict ourselves here to the stars on the periphery of the associated superbubble, and confirm that these stars at least form a coeval unit. LH 90 is a very interesting association located near 30 Doradus, and its age structure was explicitly discussed by Testor et al. (1993), who found "at least" two distinct age groups (3-4 Myr and 7-8 Myr). They attempted to assign membership of the evolved stars to one or the other of these populations based, not upon spatial locale, but on the basis of bolometric luminosity, which then assumes an answer about the progenitor masses *a priori*. They found that the α clump itself was not coeval. We have separately examined the β sub-cluster using the improved data obtained by Walborn et al. (1999) and find that the same age spread apparent in the cluster as a whole is also apparent in this subclump; the β cluster contains both a B0 I star of modest luminosity and a high luminosity O3 If* star. We are, therefore, forced to abandon this very interesting region with its large number of WR stars.

We can perform one other "reasonability test" of whether the turn-off masses are relevant for the evolved objects. What is the spatial separation between the three highest mass stars (which typically define the turn-off) and the evolved objects? We computed the projected distances, and include the *median* of these three values in Table 7, which we discuss in the next section. (We note cases where the turnoff is actually due to the binary companion.) Here we find that the median separation is 25 pc. As this is the median, there is always some massive star nearer the evolved object than the numbers shown here. This is consistent with the notion expressed in Section 1.1 that coeval massive stars may have originated in the same place, as drifts of this order are just what we expect over 3 Myr.

We can now proceed with some confidence to assign progenitor masses to the evolved stellar content of the coeval regions.

5. The Progenitor Masses and BCs

5.1. Progenitor Masses

In Table 7 we present the main results of this investigation: what are the progenitor masses of various evolved massive stars? We enclose in parenthesis values derived from clusters whose coevality is in question, and exclude the WR stars from the associations which are non-coeval.

What can be conclude from these values? First, we find that the masses of the progenitors of WRs in the SMC are higher than those of the LMC. The data are admittedly sparse, and this conclusion rests to some extent on what mass we assign to the progenitor of AB7: the three stars with the highest mass in Hodge 53 are all components of spectroscopic binaries. We can be fairly certain that the progenitor mass of AV 332 was greater than that of its companion (i.e., $> 80\mathcal{M}_\odot$), although this supposes that binary evolution itself did not play an important role in this system.

Turning to the WRs in the LMC, we find that there is a considerable range of progenitor masses for the WNEs, with minimum masses of $30\mathcal{M}_\odot$ through $60\mathcal{M}_\odot$. If the more questionable cases were included this would increase the mass range. It appears that stars covering a range of masses pass through a WNE stage, at least at LMC metallicities.

Both of the Ofpe/WN9 stars come from associations with very low lower limits— in fact, among the lowest in our sample. There is a third Ofpe/WN9 star, one located in LH 101, which also contains evolved stars of similarly low mass (as well as higher mass evolved stars). We might conclude then that the Ofpe/WN9 stars in fact are not extremely high-mass stars at all, as their association with (other) LBVs has led others to speculate. Our conclusion that Ofpe/WN9 stars are actually “low-mass” ($30\mathcal{M}_\odot$) in origin is not new with us: St-Louis et al. (1998) examined five LMC associations containing Ofpe/WN9 stars, including LH 89 and LH 101, and suggested much the same, although coevality was a concern for 3 of her 5 clusters. Schild (1987) had earlier studied LH 39, and also noticed the relative high age and low mass for this cluster containing an Ofpe/WN9 star. Using the WR standard atmosphere model, Crowther et al. (1995a) derive bolometric luminosities for Br 18 (R 84) and BE 381 that suggest (present) masses of 25 $\mathcal{M}_\odot$ and 15 $\mathcal{M}_\odot$ respectively.

Three BI + WN3 stars appear in our sample. Stars with this (composite?) type are among the brightest stars when M 33 was imaged at λ1500 with the *Ultraviolet Imaging Telescope* (Massey et al. 1996). To our knowledge, no BI + WN3 star has ever been demonstrated to have a spectroscopic orbit. We note with some interest the relatively high minimum masses for the progenitors suggested by our study here, and we believe that only radial velocity studies can resolve the nature of these objects.

The WCs come from high mass stars, but, interestingly, not significantly higher than do the WNs. Naively this would suggest that most massive stars of mass 45-50 and above go through both a WN *and* a WC stage. Similarly the WC star in the SMC, AB8, has a high minimum mass ($> 70\mathcal{M}_\odot$), not too different from the WNs in the SMC.

For the LBVs in the LMC and SMC we find extremely high minimum masses—among the highest of any stars in our study. This is in accord with the prevailing notion that they are among the highest mass stars, and owe their photometric outbursts and dramatic spectral changes to instabilities inherent to high luminosity. The two B[e] stars in our sample have substantially different masses, in accord with the suggestion B[e] stars come from a large range of luminosity (Gummersbach et al. 1995).

Although the cluster turn-offs provide only *lower limits* to the masses of the progenitors of the evolved stars, the mass functions of these and other OB associations we've studied are generally well populated (cf. Massey 1995a, 1995b). Thus these cluster turn-offs should provide substantial clues to the *actual* masses of the progenitors.

5.2. The Bolometric Corrections

We next turn to computing the BCs for these evolved stars, using the *observed* M_V of the star, and the M_{bol} of the cluster turn-off stars. Previous efforts to do this (cf. Humphreys et al. 1985) relied on the fact that little change occurs in the bolometric luminosity of a massive star as it evolves, a fact simply traced to the fact that the core mass remains relatively unaffected during main-sequence evolution. Here we propose to do somewhat better, by using the evolutionary models to make a modest correction for evolution.

Smith (1968b) introduced a narrow-band photometric system to reduce the effect of WR emission lines on photometry; her *"v"* filter is centered at λ5160 has has a zero-point tied to the system of spectrophotometric standards. For a lightly reddened star with no emission, broad-band Johnson V and Smith's v are equivalent. ($V - v = -0.02 - 0.36 \times (b - v)$ according to Conti & Smith 1972; a typical $b - v$ value for a MC WR star is -0.1 mag, e.g. Table VI of Smith 1968b. See also Turner 1982.) We therefore use the *"v"* mags listed by Breysacher et al. (1999) when available to compute M_V, using the average reddenings we find for each association. We list these values in Table 7.

We can make two assumptions for computing the BCs. The first of these is to assume that the bolometric luminosity of the WR star is the same as that of the cluster turn-off. The second is to attempt to make a correction for the luminosity evolution that the models predict. The difficulty with the latter is that what the evolutionary models predict is a very sensitive function of how mass-loss is treated, and, as we emphasized earlier in this paper, the episodic shedding of mass during the LBV phase can play an appreciable role and is difficult to model. The Geneva models do not produce WR stars when standard mass-loss rates are applied except at the very highest masses, and for this reason mass-loss rates twice that of the observed values have been assumed in some of the model calculations (e.g., Meynet et al. 1994). From the end of core H-burning (similar to the stage of the highest mass stars near the cluster turn-off) to the end of the WR phase, the evolution amounts to -1.1 mag to +0.5 mag at LMC metallicities, and +0.1 mag to +0.2 mag at SMC metallicities in the sense of $M_{\rm bol}$ at the end of core H-burning *minus* $M_{\rm bol}$ at the end of stellar models. We include the BCs in Table 7 computed both ways, using the $M_{\rm bol}$ corresponding to the end of core-H burning (i.e., the terminal age main-sequence, or TAMS) and corresponding to the adopted mass of the cluster turn-off.

We see that the BCs for the WNE stars are indeed very negative, approximately -6 mag, whether evolution is taken into account or not. This is in good accord with similar analysis of Galactic clusters by Humphreys et al. (1985) and Smith et al. (1994), although this is considerably more negative than that of even the earliest O-type stars (-5 mag). However, recent applications of the "standard WR model" applied to "weak-lined" WNE stars by Crowther et al. (1995c) have found similar values for the BCs, giving us confidence both in our method, and providing yet another indication that the models provide a solid basis for interpreting the spectra of WR stars. There is a large range present for the BCs of WNE stars shown in Table 7, with perhaps some trend with spectral subclass; i.e., more negative with earlier type. It will be interesting to see if additional atmosphere analysis produces similar results when applied to WN2 stars.

The Ofpe/WN9 stars have far more modest BCs (-2 to -4 mag); analysis by Crowther et al. (1995a) of Br 18 (R 84) BE 381 using the "standard WR model" derives BCs of -2.6 and -2.7 mag, also in good agreement with what we find.

Turning to the WCs, we find BCs of order -5.5 mag. This is a little more negative than what Humphreys et al. (1995) and Smith et al. (1994) found, although none of the WCs in their samples were as early as those studied here.

The BCs for S Dor and R 85 are very modest (-2 mag). Crowther (1997) computes a similar BC for the LBV R 127, although we note that this star is another Ofpe/WN9, or was until its outburst. We have used our own photometry obtained of HD 5980 obtained in 1985 (Massey et al. 1989b) to compute its absolute visual magnitude; given the complicated nature of this (multiple) star, it is unclear what to make if its value. The bolometric luminosity of S 134 computed by Zickgraf et al. (1986) is ~ -10, in excellent agreement with the assumptions here.

6. Conclusions, Discussion, and Summary

Our photometric and spectroscopic investigation of 19 OB associations in the Magellanic Clouds has found that most of the massive stars have formed within a short time (<1 Myr) in about half of the regions in our sample. Their degree of coevality is similar to that found by Hillenbrand et al. (1993) for NGC 6611, i.e., that the data are *consistent* with all of the massive stars "having been born on a particular Tuesday." In other regions, star-formation of the massive stars may have proceeded over a longer time, as suggested by the presence of evolved stars of 15-20$\mathcal{M}_\odot$ (suggesting ages of 10 Myr) along with unevolved stars of high mass (60 $\mathcal{M}_\odot$) with ages of only 2 Myr. In some cases such apparent non-coevality may be due to chance line-of-sight coincidences within the Clouds, or to drift of lower mass stars into the space occupied by a truly coeval OB association, but in other cases, such as the β subcluster of LH 90, one is forced to conclude that star-formation itself was not very coeval, but proceeded over several million years.

The turn-off masses of the coeval associations have provided considerable insight into the evolution of massive stars. We find that only the highest mass stars ($> 70\mathcal{M}_\odot$) become WRs in the SMC. The numbers are admittedly sparse, and an additional complication is the fact that most SMC WRs show the presence of absorption lines. Are these absorption lines indicative of a weak stellar wind (as evidenced by the weakness of the WR emission lines) or are these all due to binary companions? Conti et al. (1989) discuss this without reaching any conclusions, and we note here that the issue of the binary frequency of the SMC WR stars requires further investigation. Possibly a strong stellar wind due to very high luminosity *and* binary-induced mass-loss is needed to become a WR star in the low metallicity of the SMC.

In the LMC the mass limit for becoming a WR star would appear to be a great deal lower, possibly $30\mathcal{M}_\odot$. Stars with a large range of initial masses (30-60 $\mathcal{M}_\odot$), and possibly *all* massive stars with a mass above $30\mathcal{M}_\odot$ go through a WNE stage in the LMC. Most WR stars in the LMC are of early WN type; this is not true at the higher metallicity of the Milky Way, where WN3 and WN4 stars are relatively rare. This is consistent with recent theoretical work of Crowther (2000), who finds that varying only the abundance in synthetic WN models (holding all other physical parameters consist) changes the spectral subtype, with WNEs characteristic of low abundances, and WNLs characteristic of higher abundances. Thus, it may be the excitation classes are related neither to the masses nor to stellar temperatures.

The true LBVs occurs in clusters with very high turn-off masses ($\approx 85\mathcal{M}_\odot$), both in the LMC and the SMC. This is very similar to the turn-off mass in the Trumpler 14/16 complex with which the Galactic LBV η Car is associated (Massey & Johnson 1993). This supports the standard picture, that LBVs are an important, if short-lived, phase in the evolution of the most massive stars, at least at the metallicities that characterize the Magellanic Clouds and the Milky Way. We note with interest the important study by King, Gallagher, & Walterbos (2000), who find that some LBV stars in M 31 appear to be found in relative isolation, leading them to question whether these are all high mass stars, at least at the higher metallicity of M 31.

The Ofpe/WN9 stars, some of which go through some sort of outburst, cannot be "true" LBVs, if the nature of the latter is tied to extremely high bolometric luminosities.

We find that the Ofpe/WN9 stars have the *lowest* masses of *any* WRs, with the progenitors possibly as low as $25\mathcal{M}_{\odot}$. Similarly, the connection of the B[e] stars to LBVs seems tenuous on the basis of mass or bolometric luminosities.

We know that the relative number of WC and WN stars change drastically throughout the Local Group, in a manner well-correlated with metallicity (Massey & Johnson 1998). One obvious interpretation of this is that it is much harder to lose enough mass to become a WC star in a low-metallicity environment; i.e., only the most luminous and massive stars have sufficiently high mass-loss rates to achieve this. And, similarly, the limit for WN stars should be higher in lower metallicity systems. As long as the bar is somewhat lower for achieving WN status compared to WC status, then the IMF assures that the WC/WN ratio will change. Thus our finding here that WCs and WNs come from similar mass ranges (although higher in the SMC than in the LMC), suggest that an alternative explanation is needed. Instead, it may be that it is the relative lifetimes of the WC and WN stages which are different at different masses; i.e., at very high masses the WC stage is shorter compared to the length of the WN stage than at lower masses. Or, it could be that the metallicity itself affects the relative lifetimes of the WC and WN stages. We note that we found luminous red supergiants (RSGs) cohabiting with both WNs and WCs in many OB associations in more distant galaxies of the Local Group (Massey & Johnson 1998; see for example their Figs. 14-16). While we were unable to evaluate the degree of coevality of these associations, the statistics suggest that these stars have similar progenitor mass at a given metallicity, and that variations in the relative number of RSGs to WRs are due primarily to changes in the relative lifetimes due to the effect of metallicity on the mass-loss rates (Azzopardi, Lequeux, & Maeder 1988).

We conclude that the BCs of WNE stars are quite substantial, −6 mag. This value is in very good accord with that determined from weak-lined WNE stars using the WR "standard model" of Hillier (1987, 1990) by Crowther et al. (1995c). The earliest-type WN star known (of type WN2) is included in our sample, and our data suggest an even more striking BC (< -7.5 mag); a full analysis of Br 4 via the standard model would be of great interest. For the Ofpe/WN9 stars we find BCs of -2 to -4 mag, again in good agreement with the atmospheric analysis of several such stars by Crowther et al. (1995a). We find here that the BCs of WC4 stars are typically about -5.5 mag.

In the next paper, we will extend this study to the higher metallicities found in our own Milky Way galaxy.

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TABLE 1A

SMC Associations Used in This Study

Association[a]	H II[b] Region	Size[c] (pc)	Refs[d]	Data Used Here[d]: Photometry	Data Used Here[d]: Spectroscopy	WRs/LBVs: ID[e]	WRs/LBVs: Spectral Type[f]
NGC 346=Hodge 45	N 66, DEM 103	100×160	1	1	1	HD 5980=AB 5=AV229	WN3+abs/LBV
Hodge 53=NGC 371	N 76, DEM 123	120×160	…	New (1985)	New (1991,1992,1999)	AV 332=AB6=R 31=Sk 108	WN3+O6.5
						AB7=AV 336a	WN3+abs
NGC 602c=Hodge 69	DEM 167	45×60	2	New (1985)	New (1989,1996)	AB8=Sk 188=NGC 602c-17	WO4+O4 V

[a] OB association designations and sizes from Hodge (1985).

[b] H II region designations: "N" is from Henize (1956); "DEM" is from Davies, Elliott, & Meaburn (1976).

[c] Angular sizes from Hodge (1985) converted to parcsecs using $(m-M)_o$=18.9.

[d] References: (1) Massey, Parker, & Garmany (1989b); (2) Westerlund (1964)

[e] Star designations for the SMC: AB–Azzopardi & Breysacher (1979a); AV–Azzopardi & Vigneau (1982); R–Feast, Thackeray, & Wesselink (1960); Sk–Sandulek (1969a)

[f] Spectral classifications are from Conti, Massey, & Garmany (1989) for the SMC WRs, with some modification as described in the text.

TABLE 1B

LMC Associations Used in This Study

Association[a]	H II[b] Region	Size[c] (pc)	Refs[d]	Data Used Here[d] Photometry	Spectroscopy	WRs/LBVs ID[e]	Spectral Type[f]
LH 5=NGC 1737,43,45,48	N 83, DEM 22	90×60	1	New (1996)	New (1996,1999)	Br 4=AB-15	WN2
LH 9=NGC 1760,61	N 11, DEM 34	90×60	1,2,3	3	3	Br 9=HD 32228=R 64=Sk−66°28	WC4
LH 12=NGC 1770	N 91, DEM 39	90×60	1	New (1985)	New (1991,1992)	Br 10=HD 32402=Sk−68°15	WC4
LH 31=NGC 1858	N 105, DEM 86	60×30	1	New (1985)	New (1996)	Br 16=HD 34187=Sk−68°57	WN2.5
						MG85-1=BAT99-20	WC5+O
LH 39	DEM 110	90×30	1,4,5	New (1996)	4,New (1996)	Br 18=HDE 269227=R 84=Sk−69°79	Ofpe/WN9
LH 41=NGC 1910	N 119, DEM 132	100×60	1	New (1985,1996)	New (1996,1999)	S Dor=R 88=Sk−69°94=BE 241	LBV
						R 85=Sk−69°92=BE 241	LBV
						Br 21=HDE 269333=R 87=Sk−69°95	B1 Ia+WN3
LH 43=NGC 1923	N 40	90×45	1	New (1996)	New (1996,1999)	Br 23=Sk−65°45	WN3
LH 47=NGC1929,34,35,36	N 44, DEM 152	90×60	1,6,7	6,7	6,7	Br 25=AB-16	WN3
LH 58=NGC 1962,65,66,70	N 144,DEM 199	60	1,8	8	8, New (1999)	Br 32=HD 36521=Sk−68°80	WC4+O6.5
						Br 33=AB-1	WN3+abs
						Br 34=HDE 269546=R 103=Sk−68°82	B3I+WN3
LH 64=NGC 2001	···	120×75	1,9	New (1996)	New (1996,1999)	Br 39=HDE 26918=Sk−68°98=W16-66	WN3
LH 81=NGC 2033, 37	N 154, DEM 246	80×70	1,9	New (1985)	New (1996,1999)	Br 50=HD 37680=Sk−69°191	WC4
						Br 53=Sk−69°198=W28-30	WN4+OB
						Sk−69°194=W28-10	B0I+WN3
LH 85	···	60×45	1,9	New (1996)	New (1996,1999)	LH85-10	B[e]
						Br 63=AB-7=W27-22	WN4.5
LH 89=NGC 2042	···	130×60	1,9,10	New (1996)	10,New (1996,1999)	Br 61=AB-6	WN4
						BE381=Br 64=W27-23	Ofpe/WN9
LH 90	N 157, DEM 263SW	60×50	1,3,10,11	3,New (1985)	3,11,New (1996,1999)	Br 56	WN6
						Br 57	WN7
						Br 58=AB-4	WN5-6
						Br 62=HDE 269818=Sk−69°207	WC4
						Br 65=HDE 269828=Sk−69°209a	WN7
						TSWR1=BAT99-78	WN4
LH 101 NGC 2074	N 158, DEM 269	75×45	1,9,12	12	12, New (1996,1999)	Br 91=HDE 269927c=Sk−69°249c	Ofpe/WN9
LH 104 NGC 2081	N 158, DEM 269	90×50	1,9,10,12	New (1985)	12, New (1996)	Br 94=HD 38448=W4-7, Sk−69°255	WC5+O7
						Br 95=HD 38472=W4-16=Sk−69°258	WN3+O7
						Br 95a	WC5+O6
						S 134=HD 38489=Sk−69°259	B[e]

[a] OB association designations and sizes from Lucke & Hodge (1970).

[b] H II region designations: "N" is from Henize (1956); "DEM" is from Davies, Elliott, & Meaburn (1976).

[c] Angular sizes from Lucke & Hodge (1970) converted to parcsecs using $(m-M)_o = 18.5$.

[d] References: (1) Lucke (1972); (2) Parker et al. (1992); (3) Walborn et al. (1999); (4) Schild (1987); (5) Heydari-Malayeri et al. (1997); (6) Oey & Massey (1995); (7) Will, Bomans, & Dieball (1997); (8) Garmany, Massey, & Parker (1994); (9) Westerlund (1961); (10) Schild & Testor (1992); (11) Testor, Schild, & Lortet (1993); (12) Tester & Niemela (1998)

[e] Star designations for the LMC: Br–Breysacher (1981); BAT99–Breysacher, Azzopardi, & Testor (1999); MG85–Morgan & Good 1985; AB–Azzopardi & Breysacher (1979b,1980); R–Feast, Thackeray, & Wesselink (1960); Sk–Sandulek (1969b) W–Westerlund (1961); BE–Bohannan & Epps (1974) LH–Lucke(1972); S–Henize (1956).

[f] Spectral classifications are from Breysacher (1981), Massey & Conti (1983), and Conti & Massey (1989) for the LMC WRs, except as follows. The spectral types for the WR components of Br 9=HD 32228, TSWR1, and Br 65 are from Walborn et al. (1999) and Walborn et al. (1995), who successfully isolated these stars from their close companions using *HST*. The classification of MG85-1 is from Morgan & Good (1985). The WR nature of Sk−69° 194 is newly discovered here, and we classify the star for the first time. We propose here that R 85 be considered an LBV, based upon demonstrated photometric and spectral variability as discussed in the text. We have retained the "Ofpe/WN9" classification for Br 18, Br 64, and Br 91 (Bohannan & Walborn 1989), rather than the "WN9h" proposed for all three stars by Crowther & Smith (1997). The classification of Br 94, Br 95, and Br 95a are from Testor & Niemela (1998). The B[e] classification for S 134 is from Zickgraf (1993) and references therein; that of LH85-10 is new here.

TABLE 2

Catalog of Photometry and Spectroscopy

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
		NGC 346: See Massey, Parker, & Garmany (1998b)				
			Hodge 53			
AV332	01:03:25.82	−72:06:47.2	12.42	-0.20	−1.06	WN3+O6.5 I
h53-45	01:03:21.83	−72:04:46.5	12.54	+0.50	+0.27	Foreground?
h53-1	01:02:57.39	−72:06:44.7	12.62	+0.60	+0.32	Foreground?
h53-36	01:03:19.45	−72:06:48.3	12.73	+1.53	+0.29	Foreground?
AV337	01:03:43.23	−72:03:58.9	12.74	−0.11	−0.84	B2 I
AV339a	01:03:47.00	−72:04:21.6	12.81	+0.24	+0.12	F2 foreground?
AV342	01:03:55.10	−72:02:51.2	12.98	−0.03	−0.89	B2 I
AV331	01:03:25.94	−72:02:29.4	13.16	+0.10	+0.12	A2 I
AB7	01:03:35.93	−72:03:21.5	13.25	−0.21	−0.84	WN3+abs
AV327	01:03:11.66	−72:02:05.8	13.25	−0.22	−1.05	O9 I
h53-78	01:03:28.99	−72:06:14.7	13.40	−0.07	−0.80	B2 I
h53-141	01:03:44.37	−72:06:05.3	13.46	−0.20	−1.00	O9 III[b]
h53-47	01:03:22.07	−72:05:38.3	13.56	−0.23	−1.04	O4 V + O6.5 V
h53-137	01:03:42.96	−72:03:03.8	13.69	−0.13	−0.95	O8.5 III[b]
h53-179	01:03:54.15	−72:02:50.4	13.70	+0.06	−0.31	Foreground?
h53-206	01:04:23.92	−72:07:10.3	13.70	+0.85	+0.71	Foreground?
AV329	01:03:23.61	−72:02:30.5	13.78	−0.13	−0.93	B1.5 I
h53-79	01:03:29.14	−72:02:30.4	13.85	+0.04	−1.02	Strong nebulosity
h53-60	01:03:25.82	−72:07:07.7	13.88	−0.19	−1.01	O8 III[b]
h53-91	01:03:32.19	−72:05:23.9	13.96	−0.26	−1.01	O8.5 V
h53-27	01:03:14.57	−72:05:56.1	14.25	−0.23	−1.00	O9 V
h53-144	01:03:44.84	−72:04:19.9	14.26	+0.08	+0.00	A8 V foreground
h53-40	01:03:20.13	−72:04:13.4	14.26	−0.22	−0.83	B2 I
h53-197	01:04:07.00	−72:06:17.8	14.31	−0.19	−0.92	B1 I
h53-207	01:04:25.39	−72:05:07.8	14.32	+0.09	−1.14	Early O + nebulosity
h53-153	01:03:48.62	−72:05:05.9	14.33	−0.16	−0.91	Early B
h53-185	01:03:58.75	−72:06:24.7	14.40	−0.14	−0.91	
h53-107	01:03:35.78	−72:02:35.6	14.40	−0.03	−0.90	
h53-101	01:03:34.81	−72:03:06.8	14.42	−0.16	−1.00	
h53-119	01:03:38.23	−72:05:07.7	14.43	−0.21	−0.90	
h53-63	01:03:26.33	−72:04:07.5	14.50	−0.16	−1.00	
h53-148	01:03:46.53	−72:07:45.9	14.51	−0.16	−0.88	
h53-77	01:03:28.86	−72:06:16.7	14.56	−0.24	−1.05	
h53-69	01:03:27.70	−72:06:54.2	14.56	−0.15	−0.78	
h53-109	01:03:35.99	−72:02:45.0	14.58	−0.18	−0.97	
h53-55	01:03:23.88	−72:01:50.2	14.62	−0.14	−0.84	
h53-74	01:03:28.51	−72:06:15.0	14.66	-0.09	−0.99	
h53-103	01:03:35.76	−72:06:42.0	14.67	−0.24	−1.02	O9 V
h53-118	01:03:37.40	−72:01:29.4	14.67	−0.03	−0.98	
h53-115	01:03:37.45	−72:04:18.9	14.70	−0.07	−0.87	
h53-104	01:03:35.69	−72:05:32.4	14.71	+0.74	+0.81	
h53-130	01:03:41.26	−72:06:13.2	14.74	−0.05	−1.01	
h53-80	01:03:29.30	−72:03:44.1	14.83	−0.20	−0.88	
h53-94	01:03:32.77	−72:03:25.6	14.83	−0.15	−0.91	
h53-46	01:03:22.01	−72:05:34.0	14.85	−0.25	−0.91	
h53-73	01:03:28.36	−72:05:11.8	14.85	−0.23	−1.00	
AV345b	01:04:10.37	−72:05:57.6	14.85	−0.19	−0.85	B (type from lit.)
h53-165	01:03:52.65	−72:06:50.4	14.89	−0.20	−0.97	
h53-11	01:03:06.72	−72:06:58.2	14.90	+0.01	−0.93	
h53-99	01:03:34.43	−72:03:55.4	14.90	−0.23	−0.84	
h53-134	01:03:42.30	−72:07:44.8	14.94	−0.17	−0.81	
h53-32	01:03:16.77	−72:02:44.8	14.94	−0.17	−0.97	
h53-194	01:04:05.04	−72:06:14.2	14.97	−0.23	−0.95	
			NGC 602c			
AB8	01:31:03.75	−73:25:05.5	12.94	−0.10	−1.34	WC+O4 V
W9	01:30:59.06	−73:25:13.4	14.17	−0.23	−1.11	O7 V
W24	01:31:07.43	−73:24:15.8	14.52	+1.40	+1.99	
W30	01:31:08.14	−73:24:59.5	15.21	−0.25	−1.06	B0.5: III:
W601	01:30:42.66	−73:25:06.0	15.25	−0.18	−1.09	O6.5 V
W35	01:31:10.86	−73:25:03.2	15.52	−0.24	−0.99	B0.5 V
W40	01:31:13.83	−73:24:40.0	15.57	−0.19	−1.00	B0.5: III:
W23	01:31:06.47	−73:24:48.3	15.67	−0.26	−1.08	O9.5 V
W21	01:31:04.44	−73:24:58.6	16.26	−0.24	−0.98	B2 V
W15	01:31:04.06	−73:24:31.5	16.57	−0.20	−0.89	Early B

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
			LH5			
Sk−69°30=LH5-17=R59	04:54:14.26	−69:12:36.5	10.09	+1.55	+1.29	G5 Ia (type from lit.)
Sk−69°29=LH5-2	04:54:14.33	−69:15:13.7	12.88	−0.09	−1.06	O9 I (Slightly outside)
Sk−69°25	04:54:03.72	−69:11:57.4	12.90	−0.22	−1.05	O6 V((f))
LH5-1004	04:54:38.60	−69:11:17.7	13.41	+1.82	+0.29	
LH5-25	04:53:57.08	−69:12:36.9	13.80	−0.05	−0.85	B1 III
LH5-7	04:54:34.25	−69:09:25.1	13.80	−0.14	−0.97	B1 III
LH5-21	04:54:06.90	−69:13:52.0	14.09	+0.11	−0.35	
LH5-1008	04:54:26.12	−69:11:02.8	14.10	+0.76	−1.39	Blend
LH5-1009	04:54:24.58	−69:11:01.3	14.11	−0.19	−1.01	
LH5-9	04:54:29.77	−69:09:37.9	14.20	−0.02	−0.93	O7.5 V
LH5-1011	04:54:06.92	−69:15:17.1	14.22	+1.87	+1.78	
LH5-16	04:54:15.52	−69:12:15.8	14.51	−0.20	−1.06	O7 V
LH5-39	04:53:58.64	−69:10:23.2	14.55	+0.04	−0.98	
LH5-19	04:54:16.34	−69:13:28.4	14.60	−0.15	−0.93	
LH5-12	04:54:22.02	−69:09:46.0	14.69	−0.09	−0.97	O7.5 V
LH5-38	04:53:54.98	−69:10:20.0	14.74	+0.79	+0.02	
LH5-24	04:54:02.36	−69:12:30.3	14.77	−0.20	−1.05	O7.5 V
LH5-22	04:54:04.41	−69:13:15.4	14.87	−0.14	−0.93	
LH5-41	04:54:08.75	−69:10:38.1	14.94	−0.21	−1.05	
Br4	04:54:28.14	−69:12:51.5	16.69	−0.03	−0.79	WN2
			LH9: See Walborn et al. (1999)			
			LH12			
Sk−68°14=LH12-3	04:57:16.94	−68:24:39.1	11.05	+0.12	−1.01	B2 Ia
Sk−68°12=LH12-26	04:57:08.16	−68:25:12.6	11.41	+0.07	−0.86	B2 Ia
Sk−68°11=LH12-25	04:57:04.91	−68:24:10.8	12.19	−0.10	−0.92	B0.5 Ia
LH12-1004	04:57:05.42	−68:24:53.4	12.89	−0.15	−0.99	O8 V
Br10	04:57:24.27	−68:23:56.0	12.94	−0.10	−0.15	WC4
Sk−68°16	04:58:48.00	−68:25:00.0	12.96	−0.15	−1.01	M95: O7 III
LH12-16	04:57:25.80	−68:23:52.4	13.23	−0.07	−1.08	O8 II(f)
LH12-1008	04:57:20.22	−68:23:57.2	13.61	+0.64	+0.12	
LH12-25	04:57:10.80	−68:24:52.6	13.75	−0.16	−1.01	O8 V
LH12-34	04:57:21.41	−68:26:36.8	13.83	−0.13	−1.03	O8 V
LH12-30	04:57:16.67	−68:26:10.5	13.87	−0.18	−1.08	O4 V((f))
LH12-22	04:57:06.70	−68:24:35.2	14.00	−0.10	−0.94	B0.5 III[b]
LH12-5	04:57:25.60	−68:22:23.4	14.08	+0.30	+0.23	
LH12-1014	04:57:19.55	−68:24:02.0	14.12	−0.10	−1.04	O9 V
LH12-1015	04:57:21.97	−68:25:30.6	14.18	+0.77	+0.50	
LH12-12	04:57:20.75	−68:23:31.1	14.20	−0.10	−1.05	O8 V
LH12-13	04:57:19.80	−68:23:20.2	14.33	+1.88	+2.85	
LH12-1018	04:57:06.40	−68:24:54.1	14.45	−0.16	−1.02	O8 V
LH12-11	04:57:25.02	−68:22:46.4	14.50	+0.10	−0.98	
LH12-1020	04:57:20.62	−68:25:29.6	14.59	−0.14	−1.04	O8 V
LH12-23	04:56:56.12	−68:24:44.6	14.63	+0.17	+0.13	
LH12-24	04:57:07.68	−68:24:59.6	14.70	−0.16	−1.01	B1.5 III
LH12-20	04:57:14.44	−68:23:55.0	14.70	+1.62	+0.84	
LH12-10	04:57:35.35	−68:22:56.9	14.73	−0.14	−1.05	O8.5 V
LH12-44	04:57:27.30	−68:24:42.1	14.79	−0.21	−1.07	
LH12-1026	04:57:14.55	−68:26:31.2	14.80	−0.05	−0.77	
LH12-32	04:57:12.36	−68:26:42.2	14.84	+0.11	−0.95	
LH12-1028	04:57:13.34	−68:25:54.5	14.84	−0.18	−1.02	
LH12-1029	04:57:05.56	−68:25:13.7	14.93	−0.17	−0.98	
LH12-35	04:57:26.58	−68:26:29.5	14.97	+0.65	+0.29	
			LH31			
Sk−68°59=LH31-8	05:10: 1.04	−68:54: 8.9	12.07	−0.05	−0.83	B1 III (UBV from lit.)
LH31-1002	05:09:59.06	−68:55: 2.3	12.34	+0.41	+0.39	F2 I
LH31-1003	05:10:11.84	−68:54: 4.8	12.83	−0.16	−1.05	O6 Ib(f)
LH31-1004	05:09:57.32	−68:54:46.5	13.04	+0.61	+0.23	F7 V foreground
LH31-1005	05:09:29.18	−68:52: 0.7	13.44	−0.21	−1.05	O5 V((f))
Br16	05:09:40.36	−68:53:24.4	13.68	−0.31	−0.57	WN2.5
MG85-1	05:09:53.73	−68:52:52.2	13.93	+0.19	−0.70	WC5+O
LH31-1008	05:10: 0.31	−68:53:46.1	13.97	−0.13	−1.08	B0 V
LH31-1009	05:10: 5.38	−68:53:39.1	14.10	+0.33	+0.09	
LH31-1010	05:09:57.30	−68:54:12.6	14.21	−0.14	−1.06	O8 V

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
LH31-1011	05:09:52.23	−68:52:25.6	14.24	−0.05	−1.02	
LH31-1012	05:09:51.35	−68:54:23.4	14.34	−0.22	−1.02	O8 V
LH31-1013	05:10: 0.25	−68:53:56.3	14.35	−0.16	−1.05	
LH31-1014	05:09:54.83	−68:54:39.1	14.45	−0.16	−0.98	
LH31-1015	05:09:50.22	−68:53:49.0	14.48	+0.03	−1.00	
LH31-1016	05:09:39.73	−68:54:29.3	14.78	−0.24	−0.97	
LH31-1017	05:09:29.50	−68:52:44.0	14.91	+0.04	−0.24	
LH31-1018	05:09:57.99	−68:54:37.4	14.96	−0.14	−0.92	
LH31-1019	05:09:28.48	−68:52: 1.0	14.97	−0.16	−0.99	
LH31-1020	05:09:59.34	−68:53:27.5	14.99	−0.11	−1.10	
			LH39			
Sk−69°75=LH39-1	05:13:30.91	−69:32:24.1	10.76	+0.08	−0.77	B8 I (UBV from lit.)
LH39-2	05:13:39.62	−69:32:00.4	11.06	+0.95	+0.00	G V Foreground (UBV and type from lit.)
Sk−69°80=LH39-19	05:14:11.19	−69:32:36.7	11.16	+0.28	−0.11	B8:-F2Ia (See text)
Br18	05:13:54.38	−69:31:46.8	12.09	+0.10	−1.01	Ofpe/WN9
LH39-20	05:14:11.76	−69:33:17.9	13.08	+0.12	−0.11	S87: A3 I
LH39-1006	05:13:54.27	−69:31:58.1	13.13	+0.17	−0.93	B1 III (inconsit w/ UBV)
LH39-22	05:14:17.41	−69:33:33.3	13.58	+0.05	−0.24	S87: A1 I, New: A0 I
LH39-3	05:13:27.85	−69:31:11.9	13.63	−0.07	−0.81	S87: B2 II, New: B1 III
LH39-16	05:13:59.30	−69:31:46.9	14.02	−0.14	−0.95	S87: B1 II, New: B0.5 III
LH39-21	05:14:13.22	−69:33:24.4	14.17	−0.08	−1.11	S87: B1 IIIe
LH39-1011	05:13:55.28	−69:32:01.3	14.19	−0.17	−0.95	
LH39-9	05:13:47.91	−69:32:21.4	14.33	−0.14	−0.90	S87: B0.5 III, New: B1 III
LH39-13	05:13:51.62	−69:31:26.7	14.75	−0.14	−0.81	S87: B1 III
LH39-1014	05:14:05.53	−69:30:45.4	14.78	+1.50	+0.35	
LH39-14	05:13:56.01	−69:30:58.4	14.95	+0.49	+0.07	
LH39-5	05:13:23.70	−69:31:30.6	14.96	−0.03	−0.78	S87: B1 V
			LH41			
S Dor=Sk−69°94	05:18:14.44	−69:15:00.9	9.32	+0.11	−0.98	LBV (UBV from lit.)
R85=Sk−69°92=LH41-5	05:17:56.19	−69:16:03.8	10.53	+0.16	−0.81	LBV (AIe)
Br21	05:18:19.32	−69:11:40.6	11.28	−0.07	−0.94	B1 Ia + WN3
LH41-4	05:17:58.60	−69:15:53.9	11.38	+1.82	+1.51	M
R86	05:18:10.98	−69:13:07.4	11.52	−0.15	−1.06	B0.2 I
LH41-1006	05:18:12.05	−69:13:03.2	11.78	−0.10	−1.01	B0.5 I
Sk−69°99=LH41-37	05:18:30.28	−69:13:14.0	11.80	+0.06	−0.57	A0 I
Sk−69°104=LH41-33	05:18:59.56	−69:12:54.7	12.09	−0.20	−1.06	O7 III(f)
LH41-3	05:17:59.93	−69:16:14.6	12.10	+0.06	−0.48	A2 I
LH41-51	05:18:13.80	−69:12:01.1	12.33	−0.16	−1.03	O9.5 I
LH41-1011	05:18:11.16	−69:13:02.8	12.35	−0.17	−1.02	B0.2 I
LH41-1012	05:18:16.79	−69:15:05.5	12.42	−0.16	−1.07	O9.5 I
LH41-18	05:18:06.11	−69:14:34.5	12.57	−0.17	−1.05	
LH41-1014	05:18:11.60	−69:13:07.6	12.61	−0.15	−0.98	
LH41-1015	05:18:11.31	−69:13:05.4	12.68	−0.20	−0.97	
LH41-27	05:18:49.43	−69:14:05.4	12.79	−0.13	−1.06	O7.5 If
LH41-1017	05:18:42.49	−69:14:10.5	12.88	−0.20	−1.08	
Lh41-48	05:18:05.46	−69:12:21.3	12.89	−0.17	−1.05	B1 III[b]
LH41-1019	05:18:10.51	−69:16:56.2	12.92	−0.19	−1.03	
LH41-16	05:18:33.74	−69:15:18.2	12.93	−0.16	−1.07	O8.5 III(f)
LH41-32	05:19:01.87	−69:13:06.6	13.03	−0.20	−1.08	O4 III
LH41-58	05:18:23.74	−69:11:01.4	13.15	−0.14	−1.02	O8.5 III
LH41-34	05:18:42.44	−69:12:56.0	13.15	−0.16	−1.06	O6 III(f)
LH41-69	05:18:51.81	−69:12:06.0	13.18	−0.20	−1.05	B0 III[b]
LH41-24	05:18:48.42	−69:14:34.6	13.25	−0.19	−1.06	
LH41-44	05:18:06.44	−69:12:36.3	13.28	−0.16	−1.02	B1 III
LH41-61	05:18:34.61	−69:10:30.0	13.38	−0.13	−1.02	B0.2 III
LH41-22	05:18:31.98	−69:14:28.2	13.38	+0.67	+0.19	F5 I
LH41-35	05:18:37.18	−69:13:17.6	13.39	−0.21	−1.06	O7 III(f)
LH41-1030	05:18:42.48	−69:14:16.0	13.51	−0.19	−1.05	
LH41-57	05:18:27.12	−69:11:17.0	13.53	−0.15	−1.01	O9.5 V
LH41-10	05:18:13.06	−69:15:50.1	13.54	−0.20	−1.08	O8.5 V
LH41-71	05:19:05.76	−69:11:44.2	13.62	+1.96	+1.79	
LH41-47	05:18:14.66	−69:12:58.1	13.66	−0.19	−1.02	B0.2 III
LH41-38	05:18:33.82	−69:13:00.4	13.78	−0.18	−1.01	B1 III
LH41-1036	05:18:10.87	−69:13:20.0	13.81	−0.19	−1.02	
LH41-2	05:18:06.37	−69:16:19.3	13.82	−0.19	−1.03	
LH41-8	05:18:00.77	−69:15:04.4	13.84	−0.21	−1.06	
LH41-1039	05:18:09.03	−69:11:57.9	13.87	−0.17	−1.02	
LH41-1040	05:18:13.37	−69:13:21.2	13.90	−0.20	−1.07	

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
LH41-1041	05:18:11.26	−69:13:08.8	13.91	−0.21	−1.03	
LH41-1042	05:18:11.01	−69:13:11.3	13.95	+0.31	−1.38	
LH41-70	05:19:00.04	−69:12:04.9	13.96	−0.21	−1.05	
LH41-1044	05:18:13.40	−69:13:05.3	13.98	−0.20	−1.02	
LH41-29	05:18:59.78	−69:13:34.0	13.99	−0.22	−1.00	B0 V
LH41-1046	05:18:38.44	−69:14:18.9	14.00	−0.19	−1.05	
LH41-62	05:18:36.68	−69:10:20.0	14.01	+0.05	−0.50	
LH41-43	05:18:02.58	−69:12:48.3	14.02	−0.16	−1.00	
LH41-1049	05:18:33.94	−69:15:19.1	14.03	−0.23	−1.00	
LH41-1050	05:18:11.45	−69:16:48.3	14.05	−0.21	−1.04	
LH41-28	05:18:54.20	−69:13:40.3	14.10	−0.20	−1.06	
LH41-17	05:18:28.46	−69:14:50.5	14.11	−0.19	−1.09	
LH41-20	05:18:22.91	−69:14:13.2	14.14	−0.15	−0.89	B0.5: V:
LH41-1054	05:18:16.93	−69:15:20.7	14.17	−0.22	−1.07	
LH41-1055	05:18:48.95	−69:13:33.5	14.21	−0.19	−1.01	
LH41-55	05:18:25.74	−69:12:12.8	14.22	−0.20	−0.94	
LH41-1057	05:18:08.38	−69:16:54.2	14.23	−0.19	−1.08	
LH41-12	05:18:32.24	−69:15:47.2	14.24	−0.16	−1.03	
LH41-1059	05:18:47.24	−69:13:22.3	14.24	−0.17	−0.99	
LH41-1060	05:18:16.35	−69:15:17.0	14.25	−0.22	−1.02	
LH41-1061	05:18:12.46	−69:12:45.3	14.28	−0.17	−0.89	
LH41-1062	05:18:10.07	−69:13:09.9	14.28	−0.19	−1.08	
LH41-64	05:18:41.92	−69:10:51.7	14.32	−0.16	−1.02	
LH41-42	05:18:06.44	−69:13:11.9	14.33	−0.20	−1.00	
LH41-1065	05:18:31.45	−69:10:56.5	14.34	−0.18	−1.00	
LH41-1066	05:18:09.19	−69:10:52.7	14.35	+0.67	−0.09	
LH41-68	05:18:50.81	−69:11:28.2	14.35	−0.22	−1.00	
LH41-50	05:18:16.41	−69:12:13.2	14.36	−0.20	−0.99	
LH41-1069	05:18:31.48	−69:10:53.3	14.41	−0.03	−1.01	
LH41-1070	05:18:12.07	−69:13:22.5	14.46	−0.21	−0.99	
LH41-1071	05:18:37.99	−69:14:01.5	14.49	−0.21	−1.03	
LH41-56	05:18:21.17	−69:11:17.0	14.52	+1.87	+1.66	
LH41-60	05:18:32.65	−69:10:41.6	14.52	−0.16	−0.91	
LH41-1074	05:18:10.76	−69:16:49.8	14.53	−0.18	−0.96	
LH41-9	05:18:04.95	−69:14:52.6	14.54	−0.22	−1.03	
LH41-1076	05:18:59.03	−69:14:15.4	14.56	−0.01	−1.11	
LH41-1077	05:18:15.74	−69:15:17.8	14.57	−0.22	−1.05	
LH41-1	05:18:11.60	−69:16:36.2	14.65	−0.19	−1.09	
LH41-1079	05:18:42.65	−69:14:16.9	14.66	−0.22	−1.02	
LH41-1080	05:18:24.32	−69:11:26.7	14.67	−0.14	−0.97	
LH41-1081	05:18:10.07	−69:15:27.0	14.67	−0.23	−1.04	
LH41-15	05:18:19.91	−69:14:56.7	14.69	−0.24	−1.05	
LH41-1083	05:18:52.39	−69:13:14.2	14.74	−0.20	−0.99	
Sk−69°102	05:18:42.85	−69:14:19.9	14.75	−0.18	−1.00	O8 V
LH41-52	05:18:09.81	−69:11:36.0	14.76	−0.19	−0.93	
LH41-1086	05:18:28.00	−69:14:51.9	14.77	−0.19	−1.00	blend
LH41-11	05:18:24.51	−69:15:52.2	14.79	−0.04	−1.18	
LH41-1088	05:18:09.77	−69:12:51.5	14.81	−0.18	−0.95	
LH41-1089	05:18:03.67	−69:13:02.0	14.85	−0.22	−1.00	
LH41-1090	05:18:20.97	−69:16:57.8	14.86	−0.20	−1.00	
LH41-30	05:18:39.44	−69:13:46.8	14.89	−0.16	−0.94	
LH41-39	05:18:32.40	−69:12:48.1	14.90	−0.21	−1.02	
LH41-19	05:18:12.95	−69:14:11.6	14.90	+0.65	−0.19	
LH41-1094	05:18:49.91	−69:13:27.3	14.93	−0.18	−0.95	
LH41-1095	05:18:45.30	−69:14:18.0	14.94	−0.15	−1.07	
LH41-1096	05:18:38.98	−69:14:27.2	14.96	−0.18	−1.00	
LH41-21	05:18:28.22	−69:14:29.4	14.97	−0.22	−1.01	
LH41-40	05:18:30.75	−69:12:26.7	14.97	−0.18	−1.01	
LH41-63	05:18:34.43	−69:10:03.3	14.98	−0.19	−0.94	
LH41-1100	05:18:04.37	−69:13:06.0	14.99	−0.11	−1.14	
			LH43[c]			
LH43-15	05:20:56.02	−65:28:35.5	12.45	+1.95	+0.93	early M
Sk−65°47=LH43-18	05:20:54.67	−65:27:18.3	12.68	−0.13	−0.93	O4 If
LH43-1	05:21:03.52	−65:30:29.5	13.22	+1.27	+1.13	
Sk−65°50=LH43-14	05:21:12.26	−65:29:49.8	13.29	−0.09	−0.84	B1.5 I
LH43-13	05:21:03.42	−65:28:48.1	14.05	+0.04	−0.92	Late O/early B
LH43-2	05:20:51.47	−65:28:09.5	14.45	−0.15	−0.87	O8 V
LH43-1007	05:21:34.43	−65:29:13.6	14.63	−0.08	−0.83	O9 V
Br23	05:20:44.75	−65:28:20.7	14.73	−0.11	−0.69	WN3
LH43-10	05:21:35.77	−65:29:04.9	15.08	−0.11	−0.87	O8 V

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
LH43-9	05:20:58.20	−65:28:31.8	15.16	−0.13	−0.83	
LH43-1011	05:20:57.41	−65:27:23.0	15.18	−0.12	−0.75	
LH43-11	05:21:32.43	−65:29:04.5	15.21	−0.09	−0.80	
LH43-3	05:20:55.32	−65:27:58.3	15.34	−0.15	−0.86	
LH43-12	05:21:10.62	−65:29:16.5	15.36	−0.13	−0.81	
LH43-1015	05:20:45.32	−65:29:12.6	15.52	−0.14	−0.79	
LH43-1016	05:21:35.73	−65:29:03.2	15.81	+0.90	+0.14	Blend w/LH43-10
LH43-1017	05:20:55.58	−65:27:19.3	15.88	−0.09	−0.77	
LH43-4	05:20:55.19	−65:27:00.3	15.96	−0.14	−0.86	
			LH47: See Oey & Massey (1995)			
			LH58: See Garmany, Massey, & Parker (1994)			
LH58-496	05:26:44.0	−68:48:42	13.73	−0.23	−1.09	O3-4 V, New: O5 V((f))
			LH64[d]			
W16-1=LH64-9	05:28:41.49	−68:49:00.8	10.76	+0.50	+0.00	
LH64-3	05:29:21.09	−68:47:31.4	11.90	+2.09	+1.81	
W16-11=LH64-2	05:28:51.29	−68:46:24.0	12.23	+0.70	+0.07	
W16-26=S99-68	05:29:27.70	−68:46:00.2	12.62	−0.09	−0.80	B1 I
W16-20=S95-68	05:28:53.42	−68:48:44.2	12.66	−0.03	−0.78	B1.5: I[b]
W16-80	05:29:21.63	−68:44:11.2	12.75	+2.04	+2.00	
W16-61=LH64-70	05:29:11.67	−68:44:24.1	12.82	−0.13	−0.79	B0.5 I
W16-46=LH64-38	05:29:05.18	−68:46:04.1	12.92	−0.10	−0.78	B1: I:
W16-52=S98-68	05:29:08.37	−68:45:16.3	12.92	−0.11	−0.87	B2: III:
W16-39=LH64-34	05:29:00.88	−68:46:33.5	12.94	+2.15	+2.04	
W16-52-north	05:29:08.39	−68:45:15.1	13.32	−0.06	−0.61	Blend with W16-52
LH64-39	05:29:35.75	−68:46:23.8	13.33	−0.08	−0.75	
W16-54=LH64-28	05:29:07.43	−68:47:13.5	13.35	+0.98	+0.64	
LH64-6	05:28:36.98	−68:50:03.0	13.36	−0.09	−0.80	B1 III
W16-12=LH64-32	05:28:51.75	−68:46:44.6	13.36	+2.02	+1.98	
W16-41=LH64-53	05:29:02.75	−68:45:01.8	13.40	−0.10	−0.75	B0.5 III
LH64-4	05:29:23.24	−68:47:11.0	13.59	−0.14	−0.90	
W16-8=LH64-16	05:28:47.02	−68:47:47.8	13.62	−0.17	−0.95	O3 III:(f*)
W16-29	05:28:57.76	−68:47:20.0	13.64	−0.06	−0.79	B0.2: III:
W16-62=LH64-60	05:29:12.02	−68:44:59.2	13.74	−0.10	−0.75	B1.5 III[b]
W16-78=LH64-63	05:29:20.95	−68:44:53.3	13.74	−0.02	−0.86	
W16-32=LH64-19	05:28:58.12	−68:48:09.0	13.87	−0.11	−0.77	B0.2 III:
W16-6=LH64-7	05:28:45.80	−68:49:31.7	13.93	−0.09	−0.75	B1: III:
W16-7=LH64-33	05:28:46.59	−68:46:16.2	13.97	−0.11	−0.75	B1 III[b]
W16-65=LH64-50	05:29:12.17	−68:45:14.3	14.03	−0.16	−0.80	
W16-79=LH64-65	05:29:20.85	−68:44:34.5	14.05	−0.13	−0.72	B0.5 III[b]
W16-14=LH64-17	05:28:52.12	−68:47:59.3	14.05	+0.01	−0.32	
LH64-22	05:29:19.80	−68:48:05.4	14.09	+0.23	+0.28	
W16-67=LH64-47	05:29:13.91	−68:45:33.8	14.09	−0.14	−0.76	
W16-38=LH64-11	05:29:00.10	−68:49:26.6	14.12	−0.16	−0.85	O8.5 V
W16-85=LH64-61	05:29:24.85	−68:44:58.3	14.12	−0.14	−0.75	B2 III[b]
W16-59=LH64-73	05:29:11.10	−68:43:31.1	14.15	−0.16	−0.80	
LH64-75	05:29:27.52	−68:43:19.0	14.16	−0.18	−0.85	
W16-84=S99-68	05:29:23.89	−68:45:48.1	14.22	−0.13	−0.75	
W16-22=LH64-27	05:28:54.89	−68:47:33.4	14.35	−0.10	−0.77	
LH64-40	05:29:35.74	−68:45:48.1	14.37	−0.19	−0.90	O6 V((f))
W16-72=LH64-49	05:29:14.73	−68:45:20.8	14.37	−0.14	−0.75	
W16-71=LH64-45	05:29:18.32	−68:45:39.4	14.38	−0.19	−0.89	O5.5 III(f)
W16-58	05:29:10.53	−68:43:43.5	14.47	−0.14	−0.72	
W16-5=LH64-15	05:28:45.72	−68:48:29.7	14.50	−0.14	−0.73	
W16-49=LH64-71	05:29:06.89	−68:44:12.1	14.50	−0.15	−0.76	
W16-16=LH64-25	05:28:53.13	−68:47:33.2	14.60	−0.08	−0.71	
W16-26=LH64-11	05:28:56.67	−68:49:09.8	14.63	−0.10	−0.72	
W16-64=LH64-59	05:29:12.22	−68:44:39.9	14.65	−0.15	−0.71	
W16-43=LH64-56	05:29:03.28	−68:44:47.7	14.70	+0.81	+0.21	
W16-3=LH64-8	05:28:42.70	−68:49:17.2	14.79	−0.11	−0.73	
W16-82	05:29:22.31	−68:44:08.5	14.87	−0.17	−0.77	
W16-47=LH64-72	05:29:05.73	−68:44:07.6	14.89	−0.14	−0.67	
LH64-41	05:29:36.80	−68:45:27.0	14.96	−0.15	−0.72	
W16-27=LH64-37	05:28:57.10	−68:46:04.7	14.97	−0.11	−0.73	
W16-21=LH64-10	05:28:53.87	−68:49:30.7	14.99	+0.77	+0.10	
Br39	05:29:12.44	−68:45:36.1	15.26	−0.15	−0.58	WN3

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
			LH81			
W28-8=LH81-1	05:34:33.20	−69:46:05.8	11.10	+0.99	+1.29	G dwarf
Sk−69°200=W28-34=LH81-3	05:35:03.72	−69:45:01.9	11.22	−0.04	−0.88	B1 I
Sk−69°194=W28-10=LH81-31	05:34:36.02	−69:45:36.2	11.91	−0.07	−1.01	B0 I+WN
Sk−69°197=W28-29=LH81-48	05:34:57.89	−69:43:54.2	12.15	−0.03	−0.98	B1.5 I
Sk−69°193=W28-3=LH81-2	05:34:30.69	−69:46:51.3	12.16	−0.08	−1.02	B0.5 I
W28-20=LH81-34	05:34:47.79	−69:45:34.2	12.54	+0.94	+0.99	
LH81-1007	05:34:39.61	−69:44:47.9	12.65	−0.09	−1.02	B0 I[b]
W28-17=LH81-71	05:34:43.25	−69:42:39.1	12.81	−0.09	−0.99	B0 I
Br50	05:34:19.13	−69:45:09.8	13.01	−0.09	+0.06	WC4
LH81-57	05:34:25.99	−69:43:39.0	13.20	+0.77	+0.40	G dwarf
W28-22=LH81-72	05:34:48.31	−69:42:36.5	13.56	−0.08	−1.05	O8.5 III
W28-35=LH81-39	05:35:03.74	−69:44:47.6	13.65	−0.09	−1.12	
W28-23	05:34:50.11	−69:46:32.3	13.81	−0.16	−1.13	O3 V((f))
LH81-43	05:34:42.99	−69:44:42.6	13.81	−0.18	−1.09	O6 V((f))
LH81-5	05:34:14.64	−69:46:00.2	13.82	+0.79	+0.70	
W28-18=LH81-53	05:34:44.93	−69:43:32.9	13.84	−0.13	−1.07	O9.5 III
W28-5	05:34:28.47	−69:43:56.6	13.92	−0.18	−1.10	O4 V((f)) (N V abs.–O3.5?)
LH81-1018	05:34:41.04	−69:44:54.2	14.05	−0.14	−0.98	B0.5 III[b]
W28-14=LH81-66	05:34:37.87	−69:42:45.7	14.19	+0.65	+0.17	
W28-28=LH81-37	05:34:58.24	−69:45:08.6	14.27	−0.16	−0.96	B0 III[b]
Br53	05:34:59.56	−69:44:06.4	14.28	−0.22	−0.82	WN4+OB
LH81-20	05:34:23.77	−69:44:14.0	14.31	−0.16	−0.95	B0 III[b]
LH81-56	05:34:30.59	−69:43:41.5	14.35	−0.16	−0.98	
W28-12=LH81-32	05:34:38.10	−69:45:54.6	14.38	−0.14	−1.02	
W28-6	05:34:32.83	−69:46:57.6	14.41	−0.16	−1.08	
W28-11=LH81-29	05:34:35.89	−69:45:18.6	14.43	−0.17	−1.00	
LH81-41	05:34:55.41	−69:44:46.3	14.50	−0.13	−1.04	
W28-37-LH81-47	05:35:04.04	−69:43:52.5	14.61	−0.08	−1.03	
LH81-27	05:34:36.93	−69:44:56.9	14.77	−0.17	−0.97	
W28-9=LH81-28	05:34:32.72	−69:45:23.8	14.90	−0.19	−1.07	
LH81-1031	05:34:40.86	−69:44:50.3	14.94	−0.12	−0.93	
W28-15=LH81-64	05:34:39.04	−69:43:10.3	14.95	+0.67	+0.33	
LH81-25	05:34:33.67	−69:44:46.7	14.98	−0.14	−1.02	
LH81-24	05:34:34.90	−69:44:36.6	14.98	−0.14	−0.92	
			LH85			
LH85-26	05:35:43.89	−68:51:21.5	12.50	+2.07	+1.98	
W27-21=LH85-3	05:35:48.75	−68:53:44.7	13.07	−0.04	−0.82	B0.5 I[b]
W27-7=LH85-22	05:35:37.41	−68:51:43.0	13.16	−0.13	−0.86	B1.5:I
W27-3	05:35:25.12	−68:54:15.1	13.52	+0.00	−0.89	B0.5 I
W27-2	05:35:21.98	−68:53:36.3	13.66	+0.73	+0.14	
W27-1	05:35:12.57	−68:51:14.0	13.79	−0.20	−0.90	B0.5 III(out)
LH85-11	05:36:06.07	−68:52:21.1	13.90	+0.01	−0.78	B0.5 I
W27-8	05:35:40.15	−68:51:39.8	14.36	−0.15	−0.82	B1 III
LH85-29	05:35:35.75	−68:51:00.5	14.48	−0.18	−0.83	
LH85-32	05:35:28.58	−68:51:27.6	14.64	+0.67	+0.09	
LH85-17	05:35:35.00	−68:52:10.6	14.74	−0.15	−0.82	
W27-18	05:35:43.51	−68:51:44.3	14.74	−0.17	−0.76	B0.5 III
Br63	05:35:50.73	−68:53:39.3	14.75	−0.17	−0.98	WN4.5
LH85-16	05:35:35.77	−68:52:33.8	14.76	−0.19	−0.78	
LH85-1	05:35:42.51	−68:54:12.8	14.80	−0.14	−0.81	
W27-20=LH85-2	05:35:46.25	−68:53:34.9	14.82	−0.14	−0.81	
W27-18-SE	05:35:43.74	−68:51:45.9	14.84	−0.16	−0.81	
LH85-10	05:36:05.19	−68:52:36.0	14.91	+0.02	−0.88	B[e]
LH85-13	05:35:53.39	−68:52:27.3	14.93	−0.12	−0.78	
LH85-20	05:35:27.10	−68:52:01.2	14.97	−0.24	−0.94	
			LH89			
Sk−68°131=W27-61=LH89-105	05:36:32.45	−68:54:01.5	10.29	+0.35	+0.11	A9 Ia (UBV and type from lit.)
Sk−68°128=W27-34	05:36:10.15	−68:55:41.1	10.32	+0.42	+0.21	F3 Ia (UBV and type from lit.)
W27-6=LH89-1	05:35:44.06	−69:02:39.6	10.68	+0.50	+0.00	F8 V foreground
W27-38	05:36:16.91	−68:59:03.5	12.01	+0.66	+0.08	
Sk−69°210=W27-27=LH89-3	05:36:03.90	−69:01:29.9	12.59	+0.29	−0.71	B1.5 I
Sk−68°126=W27-5=LH89-59	05:35:38.57	−68:56:49.0	12.66	−0.05	−0.79	B1 I
Sk−68°129=W27-56=LH89-72	05:36:26.86	−68:57:31.8	12.76	+0.01	−0.83	B1 I
W27-39=LH89-70	05:36:15.79	−68:57:52.7	12.78	+1.00	+0.54	
Sk−69°199=LH89-4	05:35:13.66	−68:59:20.9	12.78	+0.06	−0.80	
W27-32=LH89-69	05:36:06.44	−68:56:40.6	12.84	+1.74	+0.15	

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
W27-40=LH89-71	05:36:17.61	−68:57:49.2	12.90	−0.05	−0.88	
W27-36	05:36:10.62	−68:54:39.9	13.03	+1.59	−0.35	
W27-58=LH89-111	05:36:26.30	−68:53:15.7	13.08	+1.35	+1.06	
W27-57=LH89-103	05:36:27.26	−68:54:18.3	13.12	+1.57	−0.07	
LH89-1015	05:36:17.41	−68:59:00.0	13.25	+0.84	+0.44	Blend w/W27-38
BE381	05:35:54.46	−68:59:07.7	13.27	+0.04	−0.86	WN9/Ofpe
W27-46=LH89-1088	05:36:15.13	−68:53:56.5	13.35	−0.07	−0.81	B1 III
W27-44=LH89-74	05:36:15.84	−68:56:51.6	13.49	−0.05	−0.91	B0.5 III[b]
W27-25=LH89-64=ST3-41	05:35:55.03	−68:57:58.9	13.50	+0.88	+0.39	
W27-55=LH89-82	05:36:23.42	−68:55:30.9	13.53	−0.08	−0.86	B0.5 III[b]
LH89-5	05:35:51.84	−69:00:52.5	13.69	+0.12	−0.84	O9.5 I
W27-48=LH89-80	05:36:20.49	−68:56:18.6	13.71	+2.20	+1.94	
W27-29=LH89-46=ST3-53	05:36:00.76	−68:58:37.5	13.75	+0.05	−0.81	ST92: B0 I
LH89-13	05:35:18.43	−68:59:07.9	13.78	−0.01	−0.87	
W27-9=LH89-53=ST3-22	05:35:46.64	−68:58:05.1	13.82	+0.01	−0.78	ST92: B1 I, New: B2 I
W27-50=LH89-97	05:36:18.33	−68:55:02.0	13.83	−0.02	−0.91	
LH89-1027	05:36:10.39	−68:54:41.3	13.88	−0.11	−0.80	
W27-31=LH89-68=ST3-62	05:36:06.76	−68:57:54.5	13.89	−0.06	−0.82	ST92: B1 I
LH89-7	05:35:16.28	−68:58:18.0	13.92	−0.14	−0.89	
W27-52=LH89-109	05:36:19.73	−68:54:03.6	13.98	+0.58	−0.06	
LH89-62	05:35:49.90	−68:57:15.1	14.00	−0.09	−0.94	
LH89-96	05:36:10.25	−68:54:56.5	14.02	−0.12	−0.81	
W27-10=ST3-27	05:35:48.75	−68:58:58.9	14.03	+0.06	−0.80	ST92: B1 I, New: B0.5: III
LH89-88	05:35:52.95	−68:54:49.0	14.04	−0.09	−0.84	
W27-41	05:36:13.51	−68:55:44.2	14.05	−0.17	−0.89	
W27-24=LH89-45=ST3-42	05:35:55.20	−68:58:56.3	14.09	−0.09	−0.89	ST92: B0 III[b]
W27-15=LH89-43=ST3-33	05:35:51.15	−68:58:57.1	14.12	+0.08	−0.95	ST92: OB+comp?, New: B0: III:
W27-59=LH89-112	05:36:28.32	−68:53:08.9	14.13	−0.16	−1.01	
W27-37=LH89-73	05:36:12.74	−68:57:08.1	14.21	−0.05	−0.82	
W27-28=LH89-64=ST3-57	05:36:02.45	−68:59:33.2	14.22	−0.04	−0.83	ST92: B0.5 V, New: B0.2 V
W27-42	05:36:14.20	−68:55:31.8	14.23	−0.07	−0.82	
LH89-30	05:35:39.81	−69:00:57.2	14.23	+0.07	−0.76	
ST3-08	05:35:37.46	−68:58:56.3	14.24	−0.06	−0.90	ST92: B0 III
W27-12=LH89-41=ST3-28	05:35:49.19	−68:59:16.4	14.29	−0.01	−0.87	ST92: B0 III[b]
W27-60=LH89-104	05:36:29.06	−68:54:14.2	14.34	−0.13	−0.85	
W27-11=ST3-29	05:35:49.28	−68:59:02.4	14.37	+0.02	−0.85	ST92: B0 III
LH89-57	05:35:43.86	−68:57:16.8	14.39	−0.11	−0.86	
LH89-1048	05:35:41.09	−69:00:20.6	14.45	+0.04	−0.59	
LH89-55	05:35:41.13	−68:57:34.4	14.46	−0.13	−0.90	
W27-54=LH89-101	05:36:22.17	−68:54:54.6	14.47	−0.11	−0.81	
W27-47=LH89-81	05:36:17.46	−68:56:09.1	14.60	−0.08	−0.87	
W27-16=LH89-49=ST3-36	05:35:51.56	−68:58:27.5	14.67	−0.08	−0.89	ST92: B0 III
W27-43=LH89-94	05:36:14.09	−68:55:21.7	14.68	−0.02	−0.98	
LH89-1054	05:36:08.99	−68:54:54.7	14.70	−0.15	−0.83	
W27-45=LH89-99	05:36:15.02	−68:54:51.0	14.70	−0.17	−0.84	
LH89-26=ST3-04	05:35:33.58	−68:58:34.6	14.73	−0.03	−0.93	ST92: B0 V
W27-17=LH89-50=ST3-37	05:35:52.67	−68:58:30.3	14.78	−0.05	−0.78	ST92: B0.5 V
LH89-61	05:35:35.58	−68:56:36.8	14.78	+0.04	−0.83	
LH89-6	05:35:12.28	−68:58:20.2	14.79	+0.23	+0.20	
LH89-29	05:35:40.45	−69:01:31.2	14.80	−0.01	−0.80	
LH89-1061	05:36:09.69	−68:54:37.6	14.81	−0.12	−0.81	
LH89-35	05:35:44.38	−68:59:36.6	14.83	+0.21	−0.80	
W27-4	05:35:30.90	−68:56:12.4	14.83	+0.04	−0.86	
LH89-85	05:35:53.66	−68:55:45.0	14.85	+1.61	+0.98	
LH89-78	05:36:16.58	−68:56:34.0	14.86	−0.14	−0.94	
W27-49=LH89-98	05:36:17.69	−68:54:49.6	14.87	−0.07	−0.93	
W27-13=LH89-42=ST3-32	05:35:50.90	−68:59:05.1	14.90	−0.03	−0.81	ST92: B0.5 V
LH89-1068	05:36:09.84	−68:55:32.7	14.91	−0.09	−0.83	
LH89-90	05:35:57.75	−68:55:22.1	14.92	−0.10	−0.82	
LH89-89	05:35:53.42	−68:54:36.9	14.96	−0.05	−0.82	
LH89-28	05:35:36.69	−69:00:11.4	14.98	−0.03	−0.85	
LH89-12	05:35:22.85	−68:58:39.6	14.98	−0.09	−0.90	
Br61=LH89-39	05:35:45.12	−68:58:44.3	15.51	−0.06	−0.96	WN4
			LH90			
Sk−69°213	05:36:17.25	−69:11:03.4	11.90	+0.15	−0.78	B1 III
Sk−69°203	05:35.27.26	−69:13:52.3	12.29	+0.01	−0.85	B1 I (slightly outside; UBV from lit.)
Sk−69°212=ST2-53	05:36:06.48	−69:11:47.3	12.31	−0.05	−0.95	O5 III(f)
LH90β-6=HM-5=ST2-38A	05:35:59.16	−69:11:50.7	12.94	+0.13	−0.76	BI+WN
HM-5Aa			13.96	···	···	(W99 HST UBV) W99: B0 I
HM-5B			14.45	+0.06	−0.75	(W99 HST UBV)

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
HM-5Ab			14.84	−0.02	−1.14	(W99 HST UBV)
HM-5C			14.59	+0.01	−0.53	(W99 HST UBV) W99: WN4, New: WN3
LH90β-13=HM-9AB	05:36:00.10	−69:11:50.3	13.05	+0.00	−0.87	W99: O4 I+, New: O3 If
ST2-71	05:36:14.48	−69:11:28.1	13.21	+0.45	−0.43	T93:B2:, New: B1.5 III
ST2-64=HM-33(δ)	05:36:11.28	−69:11:41.3	13.27	+0.23	−0.27	A0 I
Br57=ST02-104	05:35:59.90	−69:11:21.4	13.31	+0.38	−0.51	T93: WN7
Br65=LH90β-11=ST2-105	05:35:58.94	−69:11:47.3	13.34	+0.07	−0.71	T93: WN7, New: WN7+abs
ST2-08 (α)	05:35:41.69	−69:11:53.2	13.43	+0.67	−0.44	T93: O9.7I, New: B0 Ia
ST2-58=MG49	05:36:08.03	−69:12:33.7	13.60	+2.09	+1.81	T93: G8-K0
Br56=ST2-103	05:35:42.19	−69:12:33.9	13.66	+0.13	−0.73	T93: WN6
Br62	05:35:43.52	−69:10:56.2	13.72	+0.58	−0.19	T93: WC4
ST2-06=MG41(α)	05:35:40.74	−69:11:58.1	13.90	+2.44	+0.00	T93: M3 I
LH90β-9=HM-7	05:35:59.83	−69:11:49.9	13.91	+0.02	−0.90	W99: O4 III
ST2-32	05:35:55.49	−69:11:59.8	13.95	+0.11	−0.84	T93: O6:I, New: O5 III
ST2-50	05:36:04.64	−69:12:22.5	13.97	+0.03	−0.88	T93: O7 III, New: O8.5 III(f)
ST2-67(δ)	05:36:11.77	−69:11:46.7	13.98	+0.10	−0.77	T93: B1 III[b]
ST2-46	05:36:02.25	−69:11:46.8	14.00	+0.16	−0.80	T93: B0 I, New: B0 III
LH90β-7=HM-6=ST2-36	05:35:58.67	−69:11:51.4	14.02	+0.10	−0.89	T93: O8 V, New: O8.5If
TS2-19	05:35:44.14	−69:13:01.6	14.06	+0.79	+0.78	
Br58	05:35:42.27	−69:11:53.9	14.13	+0.49	−0.48	T93: WN5-6, New: O3If/WN6?
ST2-28	05:35:50.82	−69:11:59.8	14.22	+0.09	−0.84	T93: O8 V, New: O7 III
ST2-22	05:35:45.26	−69:11:35.1	14.22	+0.20	−0.79	T93: O3 III(f), New: O3 V((f))
LH90β-10=HM-8	05:35:59.74	−69:11:48.8	14.23	+0.03	−0.87	W99: O8 III
ST2-01	05:35:38.55	−69:11:16.8	14.28	+0.28	−0.63	T93: O5.5 III
ST2-63	05:36:11.13	−69:11:00.9	14.31	+0.23	−0.79	
LH90-1028	05:36:20.32	−69:12:00.6	14.35	−0.02	−0.91	B0.2 III[b](outside)
ST2-33	05:35:56.59	−69:10:38.9	14.41	+0.19	−0.79	T93: O5.5 III
ST2-21	05:35:44.74	−69:10:59.6	14.41	+0.14	−0.78	
ST2-03	05:35:40.24	−69:12:25.4	14.43	+0.28	−0.70	T93: O5.5 V
ST2-69(δ)	05:36:12.21	−69:11:42.8	14.49	+0.10	−0.96	T93: B1 V
ST2-42	05:35:59.94	−69:12:08.5	14.60	+0.28	−0.62	
ST2-62	05:36:10.87	−69:11:46.1	14.61	−0.80	+0.37	
ST2-45	05:36:01.24	−69:10:44.5	14.62	+0.21	−0.67	T93: B1 III[b]
LH90β-8=HM-11	05:35:59.82	−69:11:52.1	14.65	+0.12	−0.88	
ST2-56	05:36:07.29	−69:11:17.1	14.77	+0.13	−0.82	
ST2-65(δ)	05:36:11.31	−69:11:59.8	14.79	+0.17	−0.59	
ST2-55	05:36:07.21	−69:11:52.0	14.84	+0.02	−0.85	
ST2-18	05:35:43.71	−69:12:16.4	14.85	+0.75	+0.58	
ST2-51	05:36:05.51	−69:11:47.2	14.89	−0.01	−0.90	T93: O7 V
LH90β-4=HM-13=ST2-39	05:35:59.24	−69:11:54.4	14.92	+0.05	−0.69	
ST2-13	05:35:42.48	−69:10:40.4	14.94	+0.35	−0.64	T93: O6If
LH90-33NE	05:36:09.18	−69:12:43.0	14.95	+0.03	−0.82	
ST2-61	05:36:10.70	−69:10:41.4	15.00	+0.10	−0.59	T93: B2 III
ST2-15	05:35:43.21	−69:11:39.8	15.01	+0.09	−0.76	O8 V
LH90β-1=HM-20=ST2-35	05:35:58.63	−69:11:57.6	15.03	+0.07	−0.84	HM93: O5.5 V
LH90β-6N=HM-3=ST2-38N	05:35:59.22	−69:11:49.1	15.03	−0.17	−0.87	W99: O9 V
ST2-57	05:36:07.35	−69:12:00.3	15.07	+0.01	−0.89	
LH90β-5=HM-14=ST2-37	05:35:58.95	−69:11:53.6	15.10	+0.01	−0.89	
LH90-1051	05:36:12.74	−69:11:49.7	15.11	+0.10	−0.59	
ST2-29	05:35:51.17	−69:11:09.4	15.15	+0.23	−0.74	T93: O9: III[b]
ST2-14	05:35:42.66	−69:12:07.4	15.24	+0.26	−0.61	T93: O5.5 III
ST2-69	05:36:12.36	−69:11:44.1	15.25	+0.09	−0.68	
LH90β-12=HM-12	05:35:59.85	−69:11:54.0	15.26	+0.06	−0.84	
ST2-60	05:36:10.36	−69:11:08.6	15.27	+0.80	+0.82	
ST2-24	05:35:45.99	−69:11:24.3	15.28	+0.05	−0.81	T93: O9:
ST2-67S (δ)	05:36:11.88	−69:11:48.0	15.37	+0.01	−0.68	
ST2-48	05:36:02.86	−69:12:21.9	15.38	+0.14	−0.66	T93: B1: V[b]
ST2-59	05:36:09.33	−69:12:21.5	15.40	+0.11	−0.66	
ST2-66	05:36:11.42	−69:11:48.3	15.42	+0.11	−0.73	
ST2-52	05:36:05.68	−69:11:49.7	15.43	+0.13	−0.76	
LH90-1063	05:36:11.77	−69:11:43.9	15.47	+0.17	−0.75	
ST2-47	05:36:02.36	−69:11:58.8	15.51	+0.09	−0.74	T93: B0.5 V
LH90β-15=ST2-44	05:36:00.64	−69:11:50.1	15.52	+0.05	−0.93	T93: B0: V
ST2-20	05:35:44.51	−69:11:35.2	15.52	+0.34	−0.58	T93: O5 III
TSWR4=BAT69(α)	05:35:42.21	−69:11:52.7	17.70	···	···	(T93 UBV) T93: WC5
LH101: See Tester & Niemela (1998)						
ST5-27=W3-24	05:39:14.10	−69:30 03.8	14.58	−0.10	−1.00	TN98: O4 V, New: O3 V((f))
ST5-31=W3-19	05:39:12.20	−69:30:37.6	12.50	−0.12	−0.90	TN98: O3 If*, New: O3 If*
ST5-52=W3-14	05:39:05.41	−69:29:20.7	13.41	−0.15	−0.89	TN98: O3 V, New: ON5.5 V((f))

TABLE 2—*Continued*

Star	α_{2000}	δ_{2000}	V	$B-V$	$U-B$	Spectral Type and/or Comments[a]
			LH104			
S134=Sk−69°259=W4-26=ST4-73	05:40:13.51	−69:22:46.4	11.99	+0.23	−0.81	Z93: B[e]
W4-23(blend)=ST4-64	05:40:13.94	−69:24:02.4	12.05	+0.77	+0.73	TN98: G foreground
Br95a=W4-24A(blend)	05:40:13.34	−69:24:03.1	12.97	+0.04	−1.09	TN98: WC5+O6
W4-19=ST4-54	05:40:09.66	−69:24:23.6	13.10	−0.13	−1.07	TN98: O8I((f)), New: O8 III(f)
Br94	05:39:56.19	−69:24:24.4	13.19	−0.15	−0.58	TN98:WC5+O7
Br95	05:40:07.79	−69:24:30.9	13.25	−0.19	−0.84	TN98: WN3+O7
W4-25=ST4-61	05:40:13.69	−69:23:20.3	13.30	−0.03	−0.92	TN98: B1 I, New: B1 III
W4-11=ST4-72	05:40:03.04	−69:22:49.0	13.36	+2.00	+0.26	TN98: MI
W4-20=ST4-56	05:40:11.50	−69:23:58.2	13.41	+0.87	+0.79	TN98: G3: foreground
W4-15=ST4-47	05:40:06.42	−69:23:34.4	13.43	−0.04	−0.94	TN98: B1 I, New: B0.5 I
LH104-12	05:39:53.63	−69:22:26.4	13.65	−0.06	−0.94	
W4-4=ST4-18	05:39:50.70	−69:24:28.1	13.66	−0.02	−1.01	TN98: O5 If, New: O5If
W4-3=ST4-16	05:39:49.97	−69:23:16.6	13.97	+0.07	−0.84	TN98: B1 I, New: B0.5 III
W4-12=ST4-41	05:40:03.06	−69:24:11.5	13.97	−0.05	−0.99	TN98: B0 V, New: O9: III:
W4-6=ST4-26	05:39:54.91	−69:24:10.8	14.04	−0.10	−1.05	TN98: O6.5 V((f)), New: O7 III((f))
W4-21(blend)=ST4-55	05:40:11.00	−69:23:12.8	14.08	+0.05	−0.88	TN98: B0 V[b]
LH104-9	05:40:17.52	−69:22:19.7	14.13	−0.02	−0.88	
LH104-56	05:39:47.42	−69:25:00.1	14.28	−0.07	−1.03	
W4-2(blend)	05:39:49.95	−69:23:11.4	14.39	+0.07	−0.83	B1.5 III
W4-5=ST4-33	05:39:58.24	−69:24:14.8	14.39	−0.03	−0.94	TN98: O7 V
W4-9=ST4-35	05:39:59.63	−69:24:40.0	14.76	−0.07	−1.03	TN98: O8 V
LH104-10	05:40:09.71	−69:22:13.2	14.81	−0.09	−0.86	
W4-1=ST4-13	05:39:48.39	−69:23:17.7	14.83	−0.04	−0.82	TN98: B1 III[b]
W4-14=ST4-46	05:40:06.00	−69:23:45.2	14.87	+0.18	+0.07	TN98: A3 V foreground

[a]References for spectral types: HM93—Heydari-Malayeri et al. (1993); M95—Massey et al. (1995b); S87—Schild (1987); ST92—Schild & Testor (1992); TN98—Testor & Niemela (1998); W99—Walborn et al. (1999); Z93—Zickgraf (1993)

[b]Luminosity class adjusted based upon M_V

[c]The $U-B$ colors of L 39 may require a correction of −0.13 mag. See text.

[d]The $U-B$ colors of LH 41 may require a correction of −0.15 mag. See text.

TABLE 3
Adopted Reddenings

Association	$\overline{E(B-V)}$	$E(B-V)_{\rm min}$	$E(B-V)_{\rm max}$
	SMC		
NGC 346	0.10	0.09	0.12
Hodge 53	0.08	0.05	0.12
NGC 602c	0.07	0.03	0.14
	LMC		
LH 5	0.17	0.10	0.30
LH 9	0.07	0.03	0.11
LH 12	0.18	0.12	0.22
LH 31	0.15	0.09	0.21
LH 39	0.15	0.10	0.23
LH 41	0.12	0.05	0.17
LH 43	0.20	0.16	0.23
LH 47	0.20	0.10	0.45
LH 58	0.11	0.03	0.29
LH 64	0.14	0.08	0.18
LH 81	0.15	0.13	0.23
LH 85	0.13	0.05	0.23
LH 89	0.25	0.12	0.39
LH 90	0.40	0.20	0.60
LH 101	0.23	0.15	0.33
LH 104	0.26	0.12	0.35

TABLE 4
Summary of Transformation Equations

$E(B-V)$:	
$(B-V)_{o(\mathrm{approx})} = (B-V) - \overline{E(B-V)}$	
For $(B-V)_{o(\mathrm{approx})} \leq -0.06$,	
$\quad (B-V)_o = -0.005 + 0.317 \times Q$	
$\quad E(B-V) = (B-V) - (B-V)_o$	
with the restriction that $E(B-V)_{\mathrm{max}} \geq E(B-V) \geq E(B-V)_{\mathrm{min}}$	
For redder stars,	
$\quad E(B-V) = \overline{E(B-V)}$	
$\log T_{\mathrm{eff}}$:	
For $Q < -0.6$ and either $(B-V)_o < 0.0$ or $(U-B)_o < -0.6$,	
$\quad \log T_{\mathrm{eff}} = 4.2622 + 0.64525 \times Q + 1.09174 \times Q^2$	(V)
$\quad \log T_{\mathrm{eff}} = 5.2618 + 3.42004 \times Q + 2.93489 \times Q^2$	(III)
$\quad \log T_{\mathrm{eff}} = -0.9894 - 22.76738 \times Q - 33.09637 \times Q^2 - 16.19307 \times Q^3$	(I)
For redder stars,	
$\quad \log T_{\mathrm{eff}} = 3.96473 - 0.9056017 \times (B-V)_o + 2.442305 \times (B-V)_o^2$ $-3.423003 \times (B-V)_o^3 + 2.025585 \times (B-V)_o^4 - 0.4233297 \times (B-V)_o^5$	
Bolometric correction (BC):	
For $\log T_{\mathrm{eff}} > 4.2$,	
$\quad BC = 27.66 - 6.84 \times \log T_{\mathrm{eff}}$	
For cooler stars,	
$\quad BC = -3113.36 + 2839.618 \times \log T_{\mathrm{eff}} - 967.310 \times \times (\log T_{\mathrm{eff}})^2$ $+146.0361 \times (\log T_{\mathrm{eff}})^3 - 8.26119 \times (\log T_{\mathrm{eff}})^4$	

TABLE 5

Derived Parameters for the Highest Mass Unevolved Stars

Association	$\log T_{\rm eff}$	M_V	$M_{\rm bol}$	Mass ($\mathcal{M}_\odot$)	Age log Myr	Spectral type and/or comment
			NGC 346[a]			
N346-435=W1	4.637	-6.7	-10.7	91	6.38	O5.5 If
N346-0789=Sk80	4.590	-7.0	-10.7	85	6.43	O7 If
N346-355=W3	4.710	-5.7	-10.3	76	6.19	O3 V
N346-324	4.687	-5.2	-9.6	54	6.27	O4 V
N346-342=W4	4.652	-5.5	-9.7	53	6.45	O5.5 V
N346-368	4.652	-5.0	-9.2	43	6.45	O5.5 V
N346-470=W2	4.553	-5.4	-8.9	34	6.71	O8.5 III
			Hodge 53			
AV 332	4.606:	-6.7:	-10.6:	80:	6.4:	O6.5 I: (Component of WR binary)
h53-207	4.700:	-4.8:	-9.3:	53:	5.9:	Early O but nebular contamination.
h53-47a	4.687:	-4.9:	-9.3:	50:	6.2:	O4 V: (Component of double-lined binary)
h53-47b	4.627:	-4.9:	-8.9:	37:	6.6	O6.5 V: (Component of double-lined binary)
h53-60	4.570	-5.4	-9.0	36	6.67	O8 III:
AV 327	4.518	-5.8	-9.1	35	6.73	O9 I
h53-141	4.536	-5.8	-9.2	34	6.74	O9 III
h53-137	4.553	-5.6	-9.1	34	6.74	O8.5 III
h53-118	4.628:	-4.6	-8.6:	34:	6.5:	Photometry only
h53-91	4.571	-5.1	-8.7	32	6.70	O8.5 V
h53-11	4.621:	-4.4	-8.3:	31:	6.5:	Photometry only
h53-74	4.595:	-4.6	-8.4:	30:	6.7:	Photometry only
			NGC 602			
AB8	4.687:	-5.7:	-10.1:	68:	6.32:	O4 V: (Component of WR binary)
W9	4.613	-5.0	-8.9	36	6.60	O7 V
W601	4.627	-4.1	-8.1	29	6.41	O6.5 V
W23	4.540	-3.4	-6.8	17	6.82	O9.5 V
W30	4.450	-3.8	-6.6	13	7.22	B0.5: III:
W40	4.450	-3.6	-6.4	13	7.19	B0.5: III:
W35	4.450	-3.5	-6.3	13	7.16	B0.5 V
			LH 5			
Sk−69°25	4.639	-5.9	-10.0	64	6.35	O6 V((f))
lh5-1008	4.700:	-4.6:	-9.1:	53:	5.63:	Blend
Sk−69°29	4.518	-6.1	-9.3	40	6.63	O9 I Slightly outside boundary
LH5-9	4.600	-4.8	-8.6	34	6.47	O7.5 V
LH5-16	4.613	-4.3	-8.2	33	6.13	O7 V
Sk−69°30	3.680	-8.9	-9.3	31	6.81	G5 Ia
LH5-12	4.600	-4.3	-8.1	30	6.24	O7.5 V
LH5-24	4.600	-4.1	-7.9	29	6.10	O7.5 V
			LH 9			
LH9-30	4.518	-6.2	-9.5	45	6.60	O9 I
LH9-89	4.537	-5.9	-9.2	40	6.62	O8.5 I
LH9-62	4.585	-5.3	-9.0	38	6.55	O7.5 III
LH9-21	4.585	-4.8	-8.5	33	6.55	O8 V
LH9-84	4.556	-4.5	-8.0	26	6.65	O9 V
LH9-50	4.585	-4.0	-7.7	26	6.22	O8 V
LH9-68	4.571	-3.7	-7.3	23	6.14	O8.5 V
LH9-36	4.556	-3.7	-7.2	22	6.36	O9 V
			LH 12			
LH12-30	4.687	-5.1	-9.5	59	5.60	O4 V((f))
Sk−68°14	4.340	-8.2	-10.2	59	6.57	B2 Ia
Sk−68°16	4.601	-6.1	-9.9	58	6.45	O7 III
LH12-1004	4.585	-6.1	-9.8	55	6.48	O8 V
LH12-16	4.555	-6.0	-9.5	45	6.57	O8 II(f)

TABLE 5—*Continued*

Association	log $T_{\rm eff}$	M_V	$M_{\rm bol}$	Mass ($\mathcal{M}_\odot$)	Age log Myr	Spectral type and/or comment
Sk−68°12	4.340	-7.8	-9.8	45	6.65	B2 Ia
Sk−68°11	4.440	-6.7	-9.4	39	6.69	B0.5 Ia
LH12-34	4.585	-5.2	-8.9	37	6.55	O8 V
LH12-25	4.585	-5.2	-8.9	37	6.55	O8 V
LH12-12	4.585	-4.9	-8.6	34	6.55	O8 V
LH12-1014	4.556	-5.0	-8.5	31	6.65	O9 V
LH12-1018	4.585	-4.5	-8.2	30	6.51	O8 V
				LH 31		
LH31-1003	4.622	-6.1	-10.1	66	6.39	O6 Ib(f)
LH31-1011	4.700:	-4.9	-9.4:	59	5.59	Photometry only
LH31-1005	4.664	-5.4	-9.7	58	6.17	O5 V
iLH31-1015	4.698:	-4.7	-9.2:	54:	5.62:	Photometry only
Sk−68°59	4.372	-7.1	-9.3	36	6.72	B1 III
LH31-1010	4.585	-4.8	-8.5	32	6.54	O8 V
LH31-1012	4.585	-4.5	-8.2	29	6.49	O8 V
				LH 39		
Sk−69°75	4.050	-8.1	-8.7	25	6.88	B8 I
LH39-1006	4.372	-6.1	-8.3	23	6.89	B1 III
LH39-1011	4.472:	-4.6	-7.5:	20:	6.90:	Photometry only
LH39-3	4.372	-5.5	-7.7	19	6.99	B1 III
LH39-16	4.450	-4.9	-7.7	19	6.97	B0.5 III
Sk−69°80	3.880	-7.8	-7.9	18	7.03	B8-F2Ia
LH39-21	4.372	-4.9	-7.1	15	7.10	B1 IIIe
				LH 41		
Sk−69°104	4.601	-6.8	-10.6	86	6.37	O7 III(f)
LH41-32	4.683	-5.9	-10.2	78	6.12	O4 III
LH41-1017	4.630:	-5.9	-10.0:	62:	6.38:	Photometry only
LH41-18	4.586	-6.3	-10.0	61	6.46:	Photometry only
LH41-34	4.630	-5.8	-9.9	59	6.38	O6 III(f)
R86	4.450	-7.2	-10.0	56	6.56	B0.2 I
LH41-27	4.573	-6.2	-9.9	55	6.50	O7.5 If
LH41-24	4.611:	-5.6	-9.5:	49:	6.45:	Photometry only
LH41-1006	4.440	-7.1	-9.8	48	6.63	B0.5 I
LH41-16	4.553	-6.0	-9.5	47	6.56	O8.5 III
LH41-51	4.498	-6.5	-9.6	47	6.60	O9.5 I
LH41-35	4.601	-5.5	-9.3	44	6.49	O7 III(f)
LH41-1019	4.552:	-5.9	-9.4:	43:	6.58:	Photometry only
LH41-58	4.553	-5.9	-9.4	43	6.58	O8.5 III
				LH 43		
Sk−65°47	4.679	-6.4	-10.7	101	6.18	O4 If
LH43-2	4.585	-4.5	-8.2	30	6.51	O8 V
LH43-13	4.522:	-5.2	-8.5:	29:	6.73:	LateO/early B
LH43-1007	4.556	-4.6	-8.1	27	6.65	O9 V
LH43-10	4.585	-4.0	-7.7	27	6.26	O8 V
				LH 47[b]		
LH47-154	4.613	-5.8	-9.7	54	6.44	O7 V
LH47-192	4.657	-5.1	-9.3	50	6.08	O5 III(f)
LH47-182	4.639	-5.3	-9.4	50	6.33	O6 V
LH47-191	4.657	-4.5	-8.7	41	5.72	O5 III(f)
LH47-186	4.600	-4.9	-8.7	36	6.49	O7.5 V
LH47-338	4.613	-4.6	-8.5	35	6.33	O7 V
LH47-47	4.540	-5.5	-8.9	35	6.65	O9.5 V
LH47-15	4.556	-5.0	-8.5	31	6.65	O9 V
				LH 58[c]		

TABLE 5—*Continued*

Association	log $T_{\rm eff}$	M_V	$M_{\rm bol}$	Mass ($\mathcal{M}_\odot$)	Age log Myr	Spectral type and/or comment
Br32	4.639:	-5.9:	-9.9:	62:	6.35:	O6.5 V (Component of WR binary)
LH58-496	4.664	-5.0	-9.3	52	5.95	O5 V
LH58-694	4.518	-6.5	-9.7	51	6.56	O9 I
LH58-199	4.555	-6.1	-9.6	49	6.55	O8 I
LH58-649	4.627	-5.2	-9.2	45	6.38	O6.5 V
LH58-699	4.601	-5.5	-9.3	44	6.49	O7 III
LH58-167	4.639	-4.9	-9.0	43	6.23	O6 V
LH58-433	4.518	-5.2	-9.1	42	6.45	O7 V
LH58-419	4.518	-6.1	-9.3	41	6.63	O9.5 III
LH58-5	4.600	-5.2	-9.0	39	6.50	O7.5 V
LH58-710	4.536	-5.8	-9.2	38	6.63	O9 III
LH58-229	4.613	-4.9	-8.8	38	6.42	O7 V
				LH 64		
W16-8	4.707	-5.4	-9.9	72	5.55	O3 III:(f*)
LH64-4	4.665:	-5.4	-9.7:	58:	6.17:	Photometry only
W16-71	4.644	-4.5	-8.6	39	5.74	O5.5 III(f)
LH64-40	4.639	-4.5	-8.6	39	5.87	O6 V((f))
W16-53	4.641	-4.1	-8.1	34	5.79	Photometry only
W16-38	4.571	-4.8	-8.4	31	6.60	O8.5 V
W16-61	4.440	-6.0	-8.7	28	6.80	B0.5 I
Sk-68°99	4.420	-6.2	-8.8	28	6.81	B1 I
				LH 81		
W28-23	4.710	-5.2	-9.8	69	5.55	O3 V
Sk-69°200	4.420	-7.7	-10.3	67	6.52	B1 I
W28-5	4.687	-5.1	-9.5	58	5.61	O4 V (O3.5?)
W28-37	4.700	-4.6:	-9.1:	53:	5.63:	Photometry only
W28-6	4.700:	-4.5	-9.0:	51:	5.64:	Photometry only
LH81-43	4.639	-5.1	-9.2	46	6.29	O6 V((f))
Sk-69°193	4.440	-6.8	-9.5	40	6.68	B0.5 I
W28-22	4.553	-5.6	-9.1	39	6.61	O8.5 III
LH81-41	4.631:	-4.5	-8.5:	37:	6.04:	Photometry only
LH81-1007	4.460	-6.3	-9.1	34	6.75	B0 I
W28-12	4.597:	-4.6	-8.4:	32:	6.45:	Photometry only
Sk-69°197	4.370	-6.8	-9.1	32	6.77	B1.5 I
W28-17	4.460	-6.1	-8.9	32	6.76	B0 I
				LH85		
W27-21	4.440	-6.0	-8.7	29	6.80	B0.5 I
W27-3	4.440	-5.7	-8.4	24	6.87	B0.5 I
LH85-11	4.440	-5.3	-8.0	22	6.90	B0.5 I
W27-7	4.370	-5.5	-7.7	19	6.99	B1.5: I
				LH89		
LH89-5	4.498	-6.0	-9.1	37	6.67	O9.5 I
W27-50	4.548:	-5.5	-8.9:	36:	6.64:	Photometry only
Sk-69°210	4.370	-7.1	-9.4	36	6.72	B1.5 I
Sk-69°199	4.386	-6.8	-9.1	32	6.76	Photometry only
Sk-68°129	4.420	-6.4	-8.9	31	6.78	B1 I
				LH90		
Sk-69°212	4.657	-7.0	-11.2	119	6.23	O5 III(f)
LH90β-13	4.705	-6.4	-10.9	118	6.04	O3 If
ST2-22	4.710	-5.9	-10.5	94	5.81	O3 V((f))
LH90$\beta-9$	4.683	-5.7	-10.1	72	6.07	O4 III
ST2-01	4.644	-6.1	-10.2	71	6.32	O5.5 III
ST2-32	4.657	-5.9	-10.1	69	6.27	O5 III
ST2-03	4.652	-5.9	-10.1	69	6.29	O5.5 V
ST2-33	4.644	-5.7	-9.8	59	6.33	O5.5 III
Sk-69°213	4.372	-7.9	-10.1	57	6.58	B1 III
ST2-08	4.460	-6.9	-9.8	48	6.62	B0 Ia

TABLE 5—*Continued*

Association	log $T_{\rm eff}$	M_V	$M_{\rm bol}$	Mass ($\mathcal{M}_\odot$)	Age log Myr	Spectral type and/or comment
ST2-13	4.622	-5.4	-9.4	48	6.42	O6 If
ST2-20	4.657	-4.9	-9.0	47	5.90	O5 III
ST2-14	4.644	-5.1	-9.2	46	6.23	O5.5 III
ST2-28	4.601	-5.6	-9.4	46	6.49	O7 III
LH90β-1	4.652	-4.7	-8.9	43	5.79	O5.5 V
ST2-50	4.553	-5.6	-9.1	38	6.62	O8.5III(f)
HM-9AB	4.460	-6.4	-9.3	37	6.71	B0 I
LH90β-7	4.537	-5.7	-9.0	37	6.64	O8.5 If
Sk$-69°$203	4.420	-6.8	-9.4	37	6.71	B1 I Slightly outside boundaries
				LH 101[d]		
Sk$-69°$249	4.590	-8.1	-11.8	119	6.38	O7 If
5-31	4.705	-6.6	-11.1	119	6.07	O3 If*
5-71	4.657	-5.7	-9.9	63	6.27	O5 III
5-25	4.687	-5.2	-9.6	61	5.62	O4 V
5-52	4.652	-5.6	-9.8	59	6.29	ON5.5 V((f))
5-58	4.606	-6.1	-9.9	59	6.44	O6.5 I
Sk$-69°$249	4.460	-7.2	-10.0	57	6.56	B0 I
5-27	4.710	-4.6	-9.2	56	5.61	O3 V((f))
5-82	4.616	-5.4	-9.3	47	6.44	O6.5 III
5-23	4.613	-5.1	-9.0	40	6.44	O7 V
5-42	4.647	-4.4	-8.5	38	5.75	Photometry only
5-85	4.537	-5.6	-9.0	37	6.64	O8.5 If
5-6	4.600	-4.5	-8.3	32	6.39	O7.5V
5-1	4.580	-4.6	-8.3	30	6.54	Photometry only
5-50	4.450	-6.0	-8.7	30	6.78	B0.5 III
5-21	4.556	-5.0	-8.5	30	6.65	O9 V
5-73	4.536	-5.2	-8.5	30	6.70	O9 III
Sk$-69°$247	4.000	-8.6	-9.0	29	6.81	A0 I
5-67	4.518	-5.2	-8.4	28	6.74	O9.5 III
5-47	4.556	-4.7	-8.2	28	6.65	O9 V:
5-2	4.552	-4.5	-8.0	26	6.67	Photometry only
5-86	4.450	-5.6	-8.4	25	6.86	B0.5 III
				LH 104		
W4-4	4.651	-5.7	-9.9	62	6.29	O5 If
W4-19	4.570	-6.0	-9.6	48	6.54	O8 III(f)
W4-6	4.601	-5.1	-9.0	39	6.50	O7 III
W4-5	4.613	-5.0	-8.9	39	6.44	O7 V
LH104-12	4.556:	-5.5	-9.0:	38:	6.61:	Photometry only
W4-12	4.536	-5.3	-8.7	32	6.68	O9: III:

[a]Star identification is from Massey, Parker, & Garmany (1989b).
[b]Star identification is from Oey & Massey (1995).
[c]Star identification is from Garmany, Massey, & Parker (1994).
[d]Star identification is from Testor& Niemela (1998).

TABLE 6

Coevality and Cluster Ages and Turn-off Masses

Association	Median Age (log[Myr])		Coevality		Cluster Turn-off Mass	
	All $> 20\mathcal{M}_\odot$	3 Highest Mass	Percent	Conclude	($\mathcal{M}_\odot$)	Comments
NGC 346	6.43	6.43	86%	Yes	90	
Hodge 53	6.74	6.4:	90%	Questionable	50–80	$80\mathcal{M}_\odot$ for AV 332 comp; some evolved 10-$20\mathcal{M}_\odot$ stars)
NGC 602c	6.51	6.41	100%	Yes	70	Companion of WR binary
LH 5	6.40	6.35	86%	Yes	40	One higher mass star—binary?
LH 9	6.60	6.60	100%	Yes	45	
LH 12	6.55	6.45	87%	Yes	60	
LH 31	6.54	6.17	71%	No	65	Some evolved stars of 15-$40\mathcal{M}_\odot$
LH 39	6.99	6.89	57%	Questionable	25	Some evolved stars of $10\mathcal{M}_\odot$. Used $15\mathcal{M}_\odot$ as limit in computation.
LH 41	6.61	6.29	78%	Questionable	85	Some evolved stars of 10-$15\mathcal{M}_\odot$
LH 43	6.51	6.51	60-80%	Probably	100	
LH 47	6.47	6.33	80%	Yes	55	"Exterior" superbubble stars
LH 58	6.45	6.55	88%	Yes	50	
LH 64	6.83	6.17	77%	No	30	Unevolved stars of higher mass.
LH 81	6.71	5.61	75%	Questionable	70	Range of ages present.
LH 85	6.87	6.87	100%	Yes	30	
LH 89	6.84	6.67	95%	Yes	35	
LH 90	6.56	6.04	72%	No	>120	Evolved stars of 10-$60\mathcal{M}_\odot$
LH 90β	6.58	6.04	57%	No	>120	Evolved star of $40\mathcal{M}_\odot$
LH 101	6.56	6.38	76%	No	>120	Evolved stars of 30–$60\mathcal{M}_\odot$
LH 104	6.54	6.50	91%	Yes	60	

TABLE 7

PROGENITOR MASSES AND BOLOMETRIC CORRECTIONS

Star	Association	Spectral Type	Median Distance (parsecs)	Progenitor Mass ($\mathcal{M}_\odot$)	M_V	$M_{\rm bol}$ (TAMS)	Bol. Corr. No Evol.	Bol. Corr. With Evol.
SMC								
WNE:								
AV332	Hodge 53	WN3+O6.5	20 (0)	(>80)	...	...	...	...
AB7	Hodge 53	WN3+abs	61	(>50-80)	-5.90	-10.0 to -10.7	<-4.1 to <-4.8	<-4.3 to <-5.0
WC:								
AB8	NGC 602c	WO4+O4V	6 (0)	>70	...	...	...	...
LBV:								
HD 5980	NGC 346	WN3+abs/LBV	17	>90	-7.69[a]	-10.9	<-3.2	<-3.2
LMC								
WNE:								
Br4	LH 5	WN2	34	>40	-2.04	-9.6	<-7.5	<-7.8
Br23	LH 43	WN3	21	(>100)	-4.50	(-10.8)	(<-6.3)	(<5.3)
Br25	LH 47	WN3	30	>55	-3.52	-10.1	<-6.6	<-6.9
Br33	LH 58	WN3+abs	35	>50	-3.82	-10.0	<-6.2	<-6.2
Br61	LH 89	WN4	47	>35	-5.19	-9.3	<-4.1	<-4.5
Br53	LH 81	WN4+OB	37	(>70)	-4.58	(-10.5)	(<-5.9)	(<-5.2)
Br63	LH 85	WN4.5	28	>30	-3.93	-8.9	<-5.0	<-5.4
Br95	LH 104	WN3+O7	8	>60	-5.96	...	...	...
Ofpe/WN9:								
Br18	LH 39	Ofpe/WN9	4	(>25)	-6.57	-8.4	<-1.8	<-2.3
BE 381	LH 89	Ofpe/WN9	37	>35	-5.82	-9.3	<-3.5	<-3.9
BI+WN3								
Br21	LH 41	B1Ia+WN3	55	(>85)	-7.56	-10.7	<-3.1	<-2.0
Br34	LH 58	B3Ia+WN3	31	>50	-8.93	-10.0	<-1.0	<-1.0
Sk−69°194	LH 81	B0Ia+WN	26	(>70)	-7.06	(-10.5)	(<-3.4)	(<-2.7)
WC:								
Br9	LH 9	WC4	0.4	>45	-4.34	-9.8	<-5.4	<-5.6
Br10	LH 12	WC4	34	>60	-5.11	-10.3	<-5.2	<-5.6
Br50	LH 81	WC4	20	(>70)	-4.88	(-10.5)	(<-5.6)	(<-4.9)
Br32	LH 58	WC4+O6.5	31 (0)	>50	-6.33	...	...	...
Br94	LH 104	WC5+O7	20	>60	-5.90	...	...	...
Br95a	LH 104	WC5+O6	13	>60	-6.00	...	...	...
LBV:								
S Dor	LH 41	LBV	38	(>85)	-9.55	(-10.7)	(<-1.1)	(<-1.1)
R85	LH 41	LBVcand	66	(>85)	-8.34	(-10.7)	(<-2.3)	<-2.3)
B[e]:								
LH85-10	LH 85	B[e]	27	>30	-3.99	-8.9	<-4.9	<-4.9
S134	LH 104	B[e]	25	>60	-7.32	-10.3	<-2.9	<-2.9

[a]Pre-outburst.

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Fig. 1.— Three spectra of the suspected LBV R 85 are shown. The star was classified by Feast et al. (1960) as an B5 Iae, roughly consistent with the spectrum we obtained in January 1999. Spectra from two earlier times show a veiled appearance, with a spectral type that is cooler, based upon the lack of He I $\lambda4771$ compared to neighboring Mg II $\lambda4481$.

Fig. 2.— The spectra of two O3 If* stars are shown (LH90$\beta - 13$ and ST5-31 in LH 101), along with that of an O3 III(f*) star (W16-8 in LH 64).

Fig. 3.— The spectra of two O3 V(f*) stars, ST2-22 in LH 90 [previously classified as O3 III(f) by Testor et al. 1993], and W28-23 in LH 81. The third star, W28-5, also in LH 81, appears to be intermediate between O3 V and O4 V, as the He I $\lambda4471$ strength would imply an O4 classification, while the presence of N V $\lambda4603, 19$ absorption would suggest an O3 description.

Fig. 4.— The spectra of several early O-type dwarfs are show.

Fig. 5.— The spectra of several O-type supergiants are shown.

Fig. 6.— The star Br 58 in LH 90 has previously been called a WR star of type WN5-6 or WN6-7. We suggest here that it may be better described as one of the H-rich transition objects of type O3 If*/WN6, i.e., an O3 If* star that is so luminous that its stellar wind has come to resemble a WR star. (See discussion in Massey & Hunter 1998.) The B0I+WN star W28-10, in LH 81, is newly discovered here.

Fig. 7.— The H-R diagrams for the 19 OB associations studied here are shown. Stars for which spectral types were available are shown by filled circles; stars for which only photometry was available are shown by open circles. Asterisks represent stars with spectral types but whose location in the HRD is considered particularly uncertain, usually the components of spectroscopic binaries. The location of the stars denoted by the "+" symbol

are particularly uncertain in the HRD. The solid lines show the evolutionary tracks for the various (initial) masses as indicated. The dashed lines are isochrones at 2 Myr, 4 Myr, 6 Myr, and 10 Myr. The tracks and isochrones come from the $z = 0.001$ models of Schaller et al. (1992) for the SMC associations, and for the $z = 0.008$ models of Schaerer et al. (1993) for the LMC associations.

Fig. 8.— How much of an error in age or mass is made by misclassifying a star by a single spectral type? The tracks and isochrones shown in these HRDs are the same as in Fig. 7 computed for LMC metallicity. In (a) we show explicitly the discontinuities and gaps associated with adjacent spectral classification, as well as the systematic deviation from the ZAMS at lower masses. The upper sequence (supergiants) include spectral types O3, O4, O5, O5.5, O6, O6.5, O7, O7.5, O8, O8.5, O9, O9.5, B0, B0.2, B0.5, B1, B1.5, B2, B3, B5, B8, A0, A2, A5, A9, and F2. The middle sequence (giants) include the same spectral types, but terminating at B2. The bottom sequence (dwarfs) include the same sequence as the supergiants, but terminating at B3. In (b) we show the errors that would result for a misclassification by a single spectral subtype and/or luminosity class for representative points drawn from (a). The points shown correspond to O3 I, O6 I, O8 I, B0 I, B1.5 I, B8 I, and A5 I among the upper sequence. The four giants shown in the middle sequence are: O5.5 III, O7.5 III, O9.5 III, and B1 III. The five dwarfs shown along the bottom sequences are: O4 V, O6.5 V, O8.5 V, B0.2 V, and B2 V. The error bars extend considerably further than adjacent points in (a) because we have also included the possibility of misclassification by a luminosity class; e.g., the possibility that a star classified as an O7 III might actually be an O8 V.